NORTH COAST INTEGRATED REGIONAL WATER MANAGEMENT PLAN

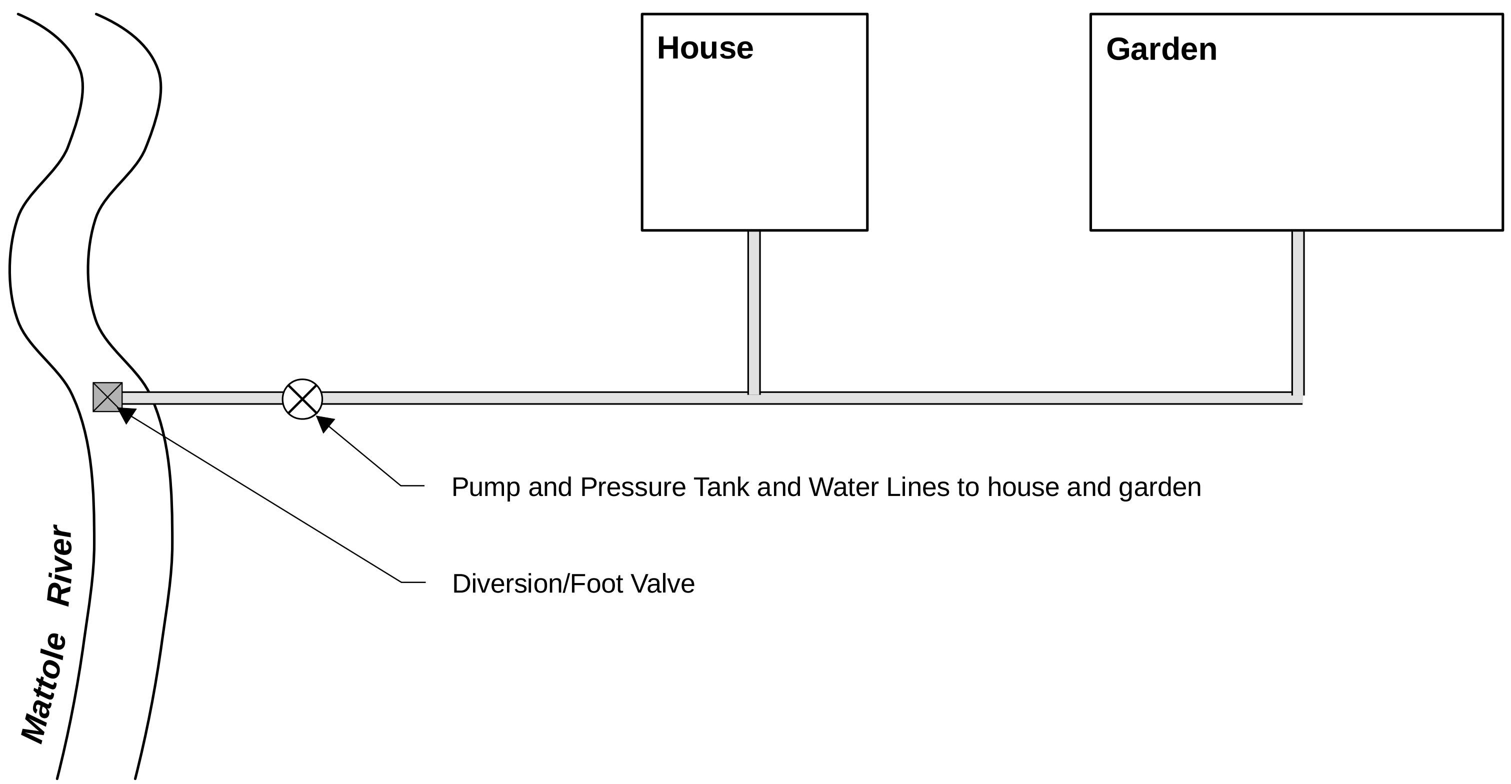
North Coast Integrated Regional Water Management Plan
Proposition 84 Round 1 Implementation Grant

Priority Project Technical Documents: Plans and Specifications

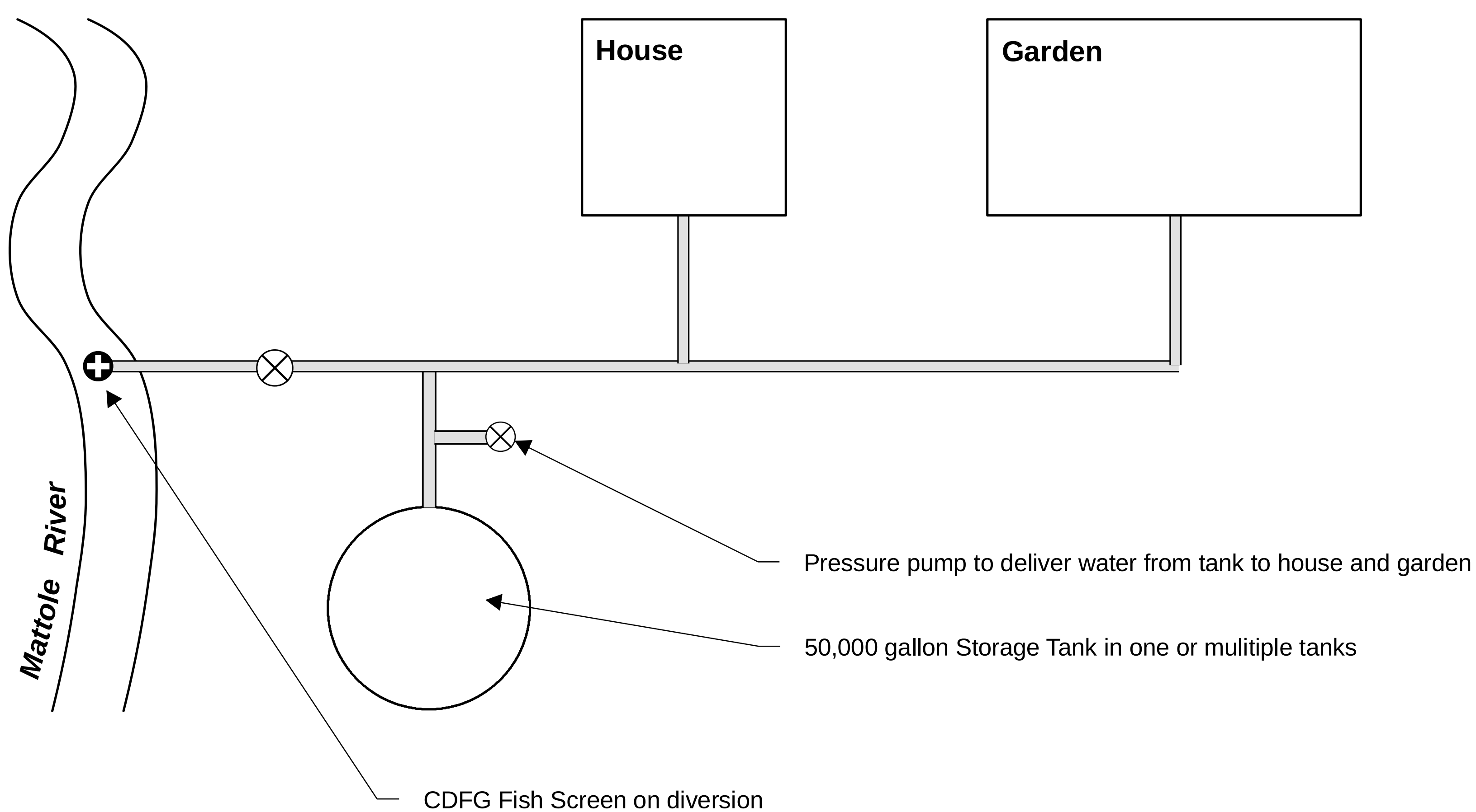
444 - Mattole Integrated Watershed Management Initiative, Mattole Restoration Council

- Mattole Restoration Council Flow Program: Water Storage and Forbearance Conceptual Plan
- Rearing Site Preliminary Plan
- Mattole Restoration Council, Sanctuary Forest, Mattole Salmon Group. Mattole Integrated Coastal Watershed Management Plan:
    - Sediment, Number 4 in the 2009 State of the Mattole Watershed Series. 2009
    - Fisheries, Number 5 in the 2009 State of the Mattole Watershed Series. 2009
    - Riparian Ecosystem Restoration, Number 7 in the 2009 State of the Mattole Watershed Series. 2009

Before Project - Existing Diversion/No Storage



After Project - Storage, Pressure Pump, Fish Screen and Leak Proofing



Mattole Flow Program: Water Storage and Forbearance Conceptual Plan

This conceptual plan is a project template that is modified for each project site. The process for completing the site specific plan includes the following:

1. Archaeology and Botany site clearance
2. California Department of Fish and Game (CDFG) water rights personnel site visit to evaluate existing diversion and modifications needed for fish protections
3. Development of landowner Water Management Plan including type and size of tank storage, exact location of tank and trench locations (requiring archaeology and botany site clearance first), system components needed to connect storage to existing system, and leak safety and controls
4. The project template is described in the plan view sketch to the left

Mattole Integrated Watershed Management Initiative

Mattole Flow Program

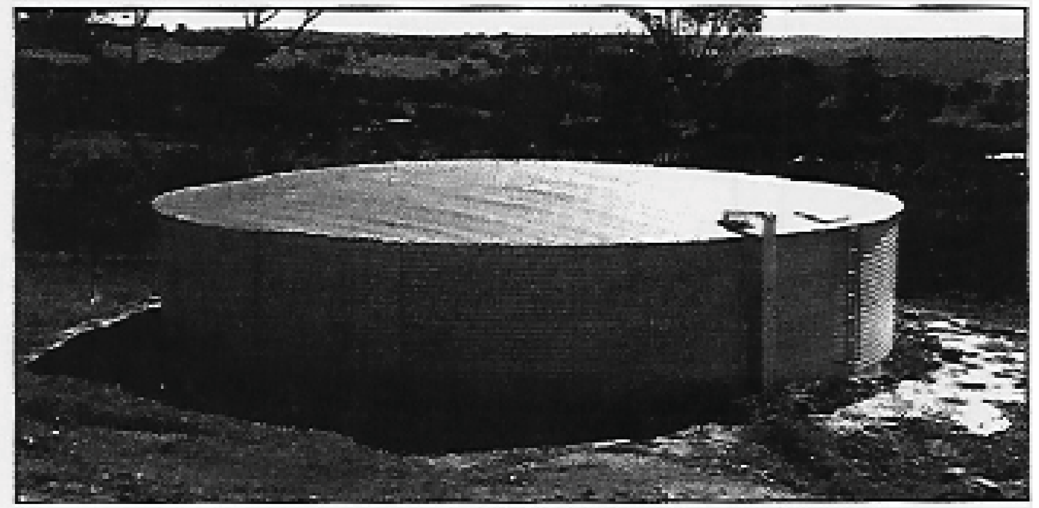
Water Storage and Forbearance Conceptual Plan

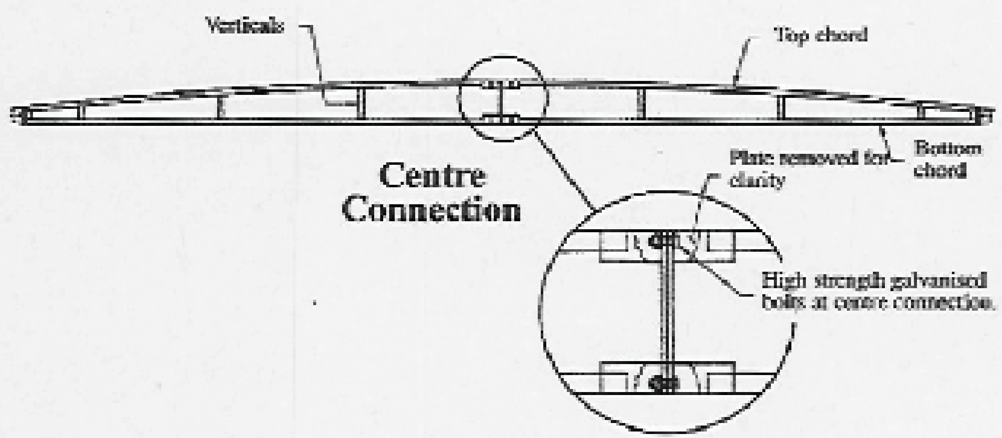
WEST COAST WATERSHED

The Pioneer Metal dome roof is a low profile roof, using hot dip galvanised trusses to support the dome roof.

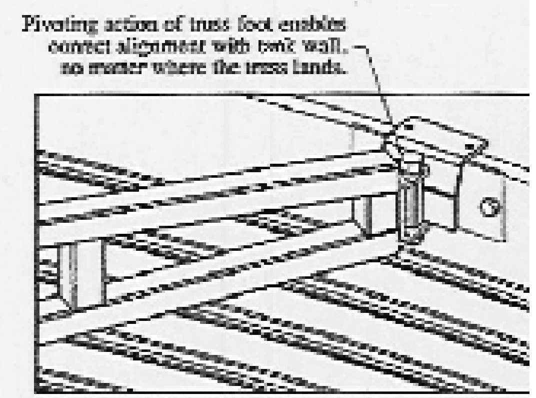
The features and advantages of the Pioneer Metal Dome Roof are:

- Heavy-duty steel super structure
  - BHP square tube steel sections.
- Hot dipped galvanising of all trusses.
- Aesthetically appealing .
- Lower profile - doesn't obstruct views.
- Can be custom made to suit existing concrete or steel tanks.
- Custom designed for high and cyclonic winds.

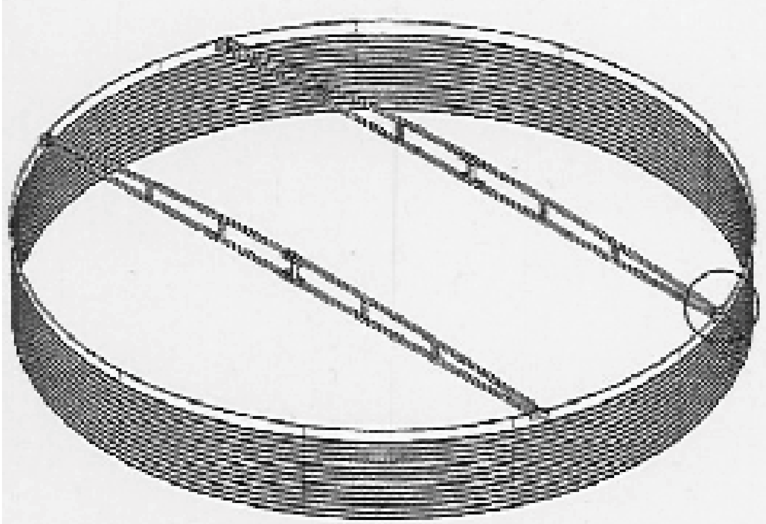




Centre Connection

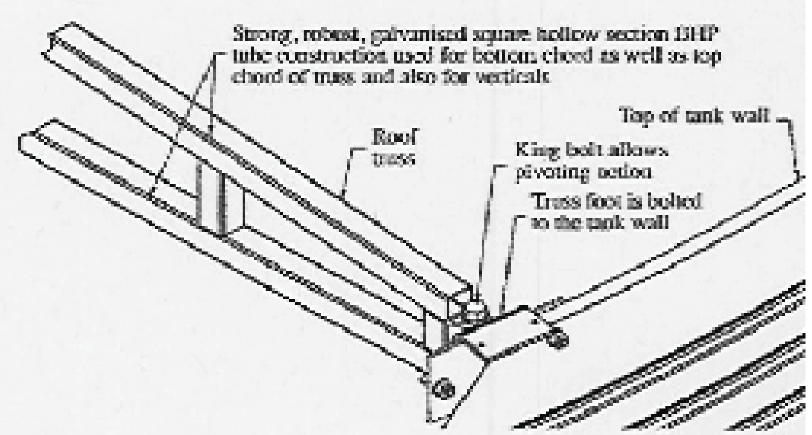


View of truss connection to tank wall from inside



Plan of Tank

Engineered roof structure design assures correctly proportioned structural elements and load transfer from the roof to the ground.



Mattole
Integrated Watershed
Management Initiative

Mattole Flow Program

Water Storage and Forbearance Conceptual Plan

Pioneer Metal Dome Roof

Fisheries

Number 5 in the
2009 State of the Mattole Watershed Series

Companion to the Mattole Integrated Coastal Watershed Management Plan

Mattole River and Range Partnership

Mattole Restoration Council
Mattole Salmon Group
Sanctuary Forest

August 31, 2009

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1. Current Conditions

A. Species Overview

Many fish species inhabit the waters of the Mattole watershed, including, but not limited to coho salmon, Chinook salmon, steelhead, sticklebacks, lampreys, and sculpins. Of these, the three species of salmonids- coho salmon, Chinook salmon, and steelhead- are listed as threatened under the Federal Endangered Species Act, and as such have been the foci of local monitoring and restoration efforts. Coho salmon are also listed as Endangered under the California Endangered Species Act. The following information describes populations of salmonids in the state of California, regulatory status, and specific information on Mattole populations and habitat.

B. California Salmonid Populations and Regulatory Status

i. Coho Salmon

The coho salmon population of the Mattole is part of the Southern Oregon/Northern California Coast (SONCC) coho salmon Evolutionarily Significant Unit (ESU), composed of populations inhabiting coastal streams between Punta Gorda, California and Cape Blanco, Oregon. Although in the 1940s SONCC coho salmon populations ranged from 150,000 to 400,000 naturally spawning fish, by the late 1990s NMFS found that SONCC coho salmon populations were "greatly diminished and … composed largely of hatchery fish," with only approximately 10,000 naturally-spawning coho salmon in the California portion of the SONCC ESU (Weitkamp et al. 1995). In 1997, NMFS listed the SONCC coho salmon ESU as a threatened species under the ESA due to a variety of factors, including habitat degradation, harvest, artificial propagation, drought, floods, and poor ocean conditions (Weitkamp et al. 1995). NMFS also concluded that existing regulatory mechanisms across the ESU were inadequate and existing conservation efforts were insufficient to conserve SONCC coho salmon. NMFS re-evaluated the status of coho salmon in 2001 and determined that it should remain a threatened species under the ESA. In 2004, the California Fish and Game Commission found that coho salmon warranted listing as a threatened species from Punta Gorda, California north to the California-Oregon border under the California Endangered Species Act (CESA), and as such published the Coho Recovery Strategy (CDFG 2004).

Based on the very depressed status of current coho salmon populations discussed above as well as insufficient regulatory mechanisms and conservation efforts over the ESU as a whole, NMFS concluded that the ESU was likely to become endangered in the foreseeable future (May 6, 1997, 62 FR 24588). A more recent status update (Good et al. 2005) indicated a continued low abundance with no apparent trends in abundance and possible continued declines in several California populations. The relatively strong 2001 brood year, likely due to favorable conditions in both freshwater and marine environments, was viewed as a positive sign, but was a single strong year following more than a decade of generally poor years (Good et al. 2005). Due to no changes in the basis for earlier listing determinations, NMFS listed the species as threatened on June 28, 2005 (70 FR 37160).

Recent adult escapement estimates document a severe decline in coho salmon populations throughout California and Oregon. Data suggests a 73% decline in 2007/2008 returning adults compared to the same cohort in 2004/2005 (MacFarlane et al. 2008).

ii. Chinook Salmon

The Chinook salmon population of the Mattole is part of the California Coastal Chinook salmon ESU, composed of populations inhabiting coastal streams from Redwood Creek in Humboldt County south through the Russian River (70 FR 52488). Chinook salmon within a given watershed may have genetically distinct populations that migrate to spawning habitat during different seasons, such as spring and fall runs, which may differ in the timing and location of spawning within a given drainage. Historically, fall-run Chinook salmon were predominant in most coastal river systems south to the Ventura River, however, their current distribution only extends to the Russian River (Healey 1991 *op cit*. Groot and Margolis 1991). Available historical and recent published Chinook salmon abundance information are summarized in Myers *et al.* (1998). The following are excerpts from this document:

> "Estimated escapement of this ESU was estimated at 73,000 fish, predominantly in the Eel River (55,500) with smaller populations in: Redwood Creek, Mad River, Mattole River (5,000 each), Russian River (500), and several small streams in Del Norte and Humboldt Counties.
>
> Within this ESU, recent abundance data vary regionally. Dam counts of upstream migrants are available on the South Fork Eel River at Benbow Dam from 1938-1975. Counts at Cape Horn Dam, on the upper Eel River are available from the 1940s to the present, but they represent a small, highly variable portion of the run. No total escapement estimates are available for this ESU, although partial counts indicate that escapement in the Eel River exceeds 4,000.
>
> Data available to assess trends in abundance are limited. Recent trends have been mixed, with predominantly strong negative trends in the Eel River Basin, and mostly upward trends elsewhere. Previous assessments of stocks within this ESU have identified several stocks as being at risk or of concern. Nehlsen *et al*. (1991) identified seven stocks as at high extinction risk and seven stocks as at moderate extinction risk. Higgins *et al*. (1992) provided a more detailed analysis of some of these stocks, and identified nine Chinook salmon stocks as at risk or of concern. Four of these stock assessments agreed with Nehlsen *et al*. (1991) designations, while five fall-run Chinook salmon stocks were either reassessed from a moderate risk of extinction to stocks of concern (Redwood Creek, Mad River, and Eel River) or were additions to the Nehlsen *et al*. (1991) list as stocks of special concern (Little and Bear Rivers). In addition, two fall-run

stocks (Smith and Russian Rivers) that Nehlsen *et al*. (1991) listed as at moderate extinction risk were deleted from the list of stocks at risk by Higgins *et al*. (1992), although the U.S. Fish and Wildlife Service reported that the deletion for the Russian River was due to a finding that the stock was extinct."

Observed widespread declines in abundance and the present distribution of small populations with sometimes sporadic occurrences contribute to the risks faced in this ESU. Based on this information, NMFS concluded that the CC Chinook salmon ESU is likely to become endangered in the near future (September 16, 1999, 64 FR 50394). More recent information for the status of CC Chinook salmon (Good *et al.* 2005) continues to support this conclusion.

Although recent specific escapement numbers for California have not been released, the Pacific Fisheries Management Council (PFMC) reported unexpectedly low numbers of Chinook salmon returning to California in 2007. The low returns were most notable in the Central Valley, where returns to the Sacramento River failed to meet resource management goals for the first time in 15 years. Although Central Valley Chinook are not included in the CC Chinook ESU, the low numbers of Chinook returning to the Central Valley are indicative of a widespread decline in California as a whole. In addition, if ocean conditions are considered as a causative factor for the 2007 cohort, then 2008 returns could result in similar numbers (MacFarlane *et al.* 2008).

iii. Steelhead

The steelhead population of the Mattole is part of the Northern California Steelhead Distinct Population Segment, composed of populations inhabiting coastal streams from Redwood Creek in Humboldt County south through the Gualala River (70 FR 52488). Available historical and recent published steelhead abundance is summarized in the NMFS west coast steelhead status review (Busby *et al.* 1996). The following are excerpts from this document:

"Prior to 1960, estimates of abundance specific to this ESU were available from dam counts in the upper Eel River (Cape Horn Dam annual average of 4,400 adult steelhead in the 1930s), the South Fork Eel River (Benbow Dam annual average of 19,000 adult steelhead in the 1940s), and the Mad River (Sweasey Dam annual average of 3,800 adult steelhead in the 1940s).

In the mid-1960s, estimates of steelhead spawning populations for many rivers in this ESU totaled 198,000. The only current run-size estimates for this area are counts at Cape Horn Dam on the Eel River where an average of 115 total and 30 wild adults were reported.

Adequate adult escapement information was available to compute trends for seven stocks within this ESU. Of these, five data series exhibit declines and two exhibit increases during the available data series, with a range from 5.8% annual decline to 3.5% annual increase. Three of the declining trends were significantly different from zero. We have little information on the actual contribution of hatchery fish to natural spawning, and little information on present total run sizes for this ESU. However, given the preponderance of significant negative trends in the available data, there is concern that steelhead populations in this ESU may not be self-sustaining."

Schiewe (1997) summarized more recent data on trends in abundance for summer and winter steelhead in the Northern California ESU. The following are excerpts from this document:

> "Updated spawner surveys of summer steelhead in Redwood Creek, the south fork of the Van Duzen River (Eel River Basin), and the Mad River suggest mixed trends in abundance: the Van Duzen fish decreased by -7.1% from 1980-96 and the Mad River summer steelhead have increased by 10.3% over the same time period. The contribution of hatchery fish to these trends in abundance is not known.
>
> New weir counts of winter steelhead in Prairie Creek (Redwood Creek Basin, Humboldt County) show a dramatic increase (over 36%) in abundance during the period 1985-1992. This increase is difficult to interpret because a major highway construction project during this time period resulted in intensive monitoring of salmonids in the basin and Prairie Creek Hatchery was funded to mitigate lost salmonid production. Therefore, it is unclear whether the increase in steelhead reflects increased monitoring effort and mitigation efforts or an actual recovery of Prairie Creek steelhead."

In 2000, NMFS concluded that the status of the population had changed little since the 1997 evaluation. Based on this and a lack of implementation of State conservation measures, NMFS concluded that the Northern California steelhead ESU warrants listing as a threatened species (June 7, 2000, 65 FR 36074). The more recent review of the status of NC steelhead (Good *et al.* 2005) indicated that the ESU is still likely to become endangered.

C. Local Populations

The Mattole watershed populations of coho salmon, Chinook salmon, and steelhead are all considered Functionally Independent Populations of their respective Evolutionarily Significant Units (Bjorkstedt et al. 2005, Williams et al. 2006). The concept is described in NMFS Technical Memorandum, *An Analysis of Historical Population Structure for Evolutionarily Significant Units of Chinook salmon, coho salmon,* *and steelhead in the North-Central California Coast Recovery Domain* (Bjorkstedt *et al.* 2005):

"Functionally Independent Populations are those with high likelihood of persisting over 100-year time scales and conform to the definition of independent viable salmonid populations. The concept considers independently two characteristics of a population: *viability*, defined in terms of probability of extinction over a specified time frame, and *independence*, defined in terms of the influence of immigration on a population's extinction probability. Following McElhany *et al.* (2000), we define a "viable" population as a population having a low (<5%) probability of going extinct over a 100-year time frame, and define an "independent" population as one for which exchanges with other populations have negligible influence on its extinction risk, estimated over a similar time frame."

D. Abundance

i. Outmigrants

The 2008 season marked the 23rd consecutive year of the MSG's Juvenile Salmonid Migrant Monitoring program. The MSG has conducted annual population monitoring of juvenile salmonids (by downstream migrant trapping in spring and early summer) in the lower mainstem Mattole River since 1985 (using a fyke trap through 1996, and a 1.5 m rotary screw trap thereafter), in lower Bear Creek from 1997-2003 (pipe trap), in the middle mainstem Mattole near Ettersburg from 2001-2003 (pipe trap), in lower Squaw Creek in 2006 (pipe trap), and in the Lower North Fork in 2008 (fyke trap).

There are many factors that can contribute to variation in catch totals throughout any given trapping season independent of actual population fluctuations such as variation in river flow and temperature patterns, which can and do vary. Water years can be interpreted to a certain extent by looking at spring flows and the date of initial river mouth closure. In years when river flows are low and water temperatures are high, fish tend to emigrate earlier in the spring and summer seasons. In years when river flows remain high and temperatures remain low, fish emigrate all the way through late summer. In addition, trapping efficiency is directly related to the percentage of river flow sampled by a trap, and in years with higher or lower river flows, a smaller or larger percentage of the river is sampled respectively. Variations in trap efficiency directly influence the margin of error in any population estimate.

Another factor that contributes to the accuracy of juvenile salmon abundance estimates is the number of days during a given year that are sampled. MSG funding for downstream migrant trapping varies from year to year and with it the number of days that are able to be sampled. The more days that are sampled during the emigration period of any given species, the more accurate the abundance estimate.

Table 1 presents catch totals and population estimates for juvenile Chinook salmon captured at the lower mainstem Mattole River trapping station at River-mile 3.8 for the 2001-2007 seasons. The modified 1-site version of the Rawson model as described by Carlson *et al*. (1998) was used for creating population estimates for the 2006 and 2007 seasons and is based on weekly trap efficiencies. Population estimates for the previous year's data were made using an average trap efficiency for the entire season. Based on these population estimates, 2001 actually had the largest estimated abundance (345,619) in the 2001-2007 years analyzed, even though 2007 had the largest catch total (it is worth noting that in 2001, only one trap efficiency trial was conducted, compared to an average of 5-10 trials per season). The lowest estimated abundance from 2001–2007 was in 2004, with an estimate of 7,432 Chinook salmon. Based on the scale sample analysis conducted for the MSG's 2005-2006 Adult Escapement Estimate project, it appears that the majority of Chinook salmon return at four years of age. For two out the last three four-year cycles, Chinook salmon juvenile estimates have increased. Chinook catch totals ranged from a low of 7,432 to a high of 345,619 over the 2001 to 2007 monitoring seasons.

Table 1: Juvenile Chinook catch total, population estimates and associated data collected at the MSG Downstream Migrant Trapping station in the lower mainstem Mattole River, 2001-2007.

Year	Yearly Catch Total	Population Estimate	# of days sampled	Average Trap Efficiency (%)	Date of Mouth Closure*
2001	7,258	345,619	57	2.1	3-Jun
2002	7,359	38,732	46	19.0	13-Jun
2003	3,185	22,914	46	13.9	8-Aug
2004	2,304	7,432	24	31.0	27-Jun
2005	3,229	15,303	37	21.1	16-Aug
2006	8,008	78,928	57	13.7	23-Jul
2007	10,953	151,404	63	9.0	6-Jun

*Initial date of mouth closure

Based on data collected during downstream migrant trapping operations, coho salmon juveniles in the Mattole River tend to emigrate from early March through early May, with over 99% of these fish being one year old smolts; however it is unknown what proportion of the population emigrates prior to installation of traps in the spring. Data presented for coho salmon juveniles in Table 2 are from 2001-2007. Coho salmon smolt catch totals in 2007 (222) were considerably lower than in 2006 (452), although trapping commenced a full month earlier in 2007. In 2004, the lowest numbers of coho salmon were recorded; this could in part be due to high streamflows in the spring, which delayed the initiation of trapping until after the majority of coho salmon juveniles had already emigrated. Overall, numbers for the 2006 and 2007 season showed a large increase in coho smolts as compared with the previous five years of data. Due to extremely low catches, not enough juvenile coho salmon are available for estimating trap efficiencies, and therefore no population estimates were calculated.

Table 2: Coho salmon smolt catch data collected at the MSG Downstream Migrant Trapping station in the lower mainstem Mattole River, 2001-2007.

Year	Coho salmon catch totals	# of days sampled	Commencement of trapping
2001	33	57	3-May
2002	80	46	7-May
2003	14	46	20-May
2004	3	24	13-Jun
2005	70	37	13-May
2006	452	57	3-May
2007	222	63	9-Apr

Table 3 presents data collected on steelhead juveniles from 2001-2007. Steelhead young of the year (YOY) catch totals in 2007 were similar to previous years, with large pulses of YOY captured toward the end of the season when flows receded and temperatures climbed. This appears to be a common trend for steelhead in the Mattole River. During the 2007 season, 35,847 YOY, 1,834 parr, and 309 smolts were captured, as compared with 15,461 YOY, 712 parr, and 189 smolts for the 2006 season. Steelhead parr and smolt catch totals were higher in 2007 compared to 2006, however both years showed much higher catch totals than the previous five years. The lowest catch totals were in 2005, however the 2005 season had two large rain events that kept flows high and water temperatures cool for most the migratory period. Young of the year are generally classified as being less than 65 mm, and parr and smolts are differentiated by the degree of silvery coloration and distinctness of parr marks.

Table 3: Juvenile steelhead data collected at the MSG Downstream Migrant Trapping station in the lower mainstem Mattole River, 2001-2007.

Year	SH Smolts	SH Parr	SH YOY	# of days sampled	Commencement of trapping
2001	104	1,025	45,378	57	3-May
2002	19	605	49,878	46	7-May
2003	28	647	17,439	46	20-May
2004	51	202	25,873	24	13-Jun
2005	18	101	1,301	37	13-May
2006	159	742	15,461	57	3-May
2007	309	1,834	35,847	63	9-Apr

ii. Adults

A common memory among Mattole old-timers is that one could walk across the river on the backs of the salmon during the fall salmon runs. This measure of abundance may sound mythical, but qualitative population estimates of historical runs of adult coho salmon, Chinook salmon, and steelhead abundance help to convey a sense of what was lost. In l960, US Fish and Wildlife personnel extrapolated from the extent of existing spawning gravels that 10,000 pairs could potentially utilize the watershed. DFG (1965) made similar historical population estimates of 5,000 Chinook salmon, 2,000 coho salmon, and 12,000 steelhead. NOAA Fisheries reported the same historical estimate of Chinook salmon at 5,000 individuals (Myers *et al.* 1998).

Since 1960, further declines have been documented, with most observers indicating severe declines in the early 1980s, which spurred the organization of the MSG who, in conjunction with local residents, initiated spawning surveys in l981. Spawning surveys do not have the capacity to count every fish that enters the watershed. However, through data collected, population estimates were made from 1981 to 1995, and indices of escapement were calculated from 1994 to 2008, based on number of redds per accumulated survey mile. The Escapement Index does not give specific escapement estimates, but rather documents population trends based on visual observations. Absolute escapement estimates are not made due to difficulties and/or variations in flow, access to property, and project funding from year to year.

Figure 1 below documents total live fish counts in the Mattole for the 1994-95 through 2007-08 seasons. Live fish counts vary from year to year based on access to private property, flows, visibility, funding, and availability of staff. Numbers of live adult Chinook salmon have ranged from 21 (1997-98) to 329 (2005-06). Coho salmon numbers have ranged from 7 (1994-95) to 86 (2004-05) adults, and steelhead counts have ranged from 0 (1997-98) to 177 (2000-01) adults. Likewise, Figure 2 documents Escapement Indices for Chinook salmon and coho salmon from the 1994-95 through 2007-08 seasons. Although specific escapement estimates of adult salmonids cannot be made in the Mattole watershed, a conjecture can be made based on historical knowledge, anecdotal evidence, and annual surveys, at least for Chinook and coho salmon. We have no abundance estimates for steelhead, although juvenile steelhead are much more abundant throughout the watershed than salmon. Although Chinook salmon populations have increased from the low hundreds of the early 1990s, there are no signs in our data that indicate the population has increased to the thousands. Current estimates of Chinook salmon are believed to be in the mid to high hundreds, approximately between 300 and 800 individuals. Based on the low numbers observed during spawning surveys and downstream migrant trapping, the MSG believes the Mattole coho salmon population is in the low hundreds, at best.

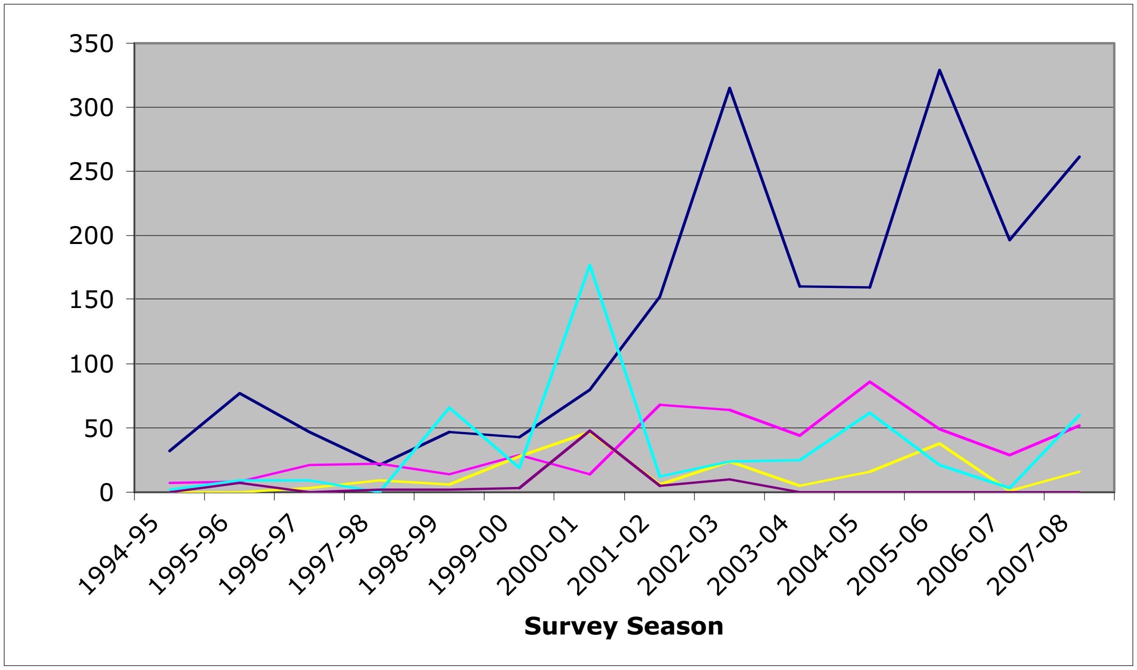

Figure 1: Total Live Fish counts of adult Chinook salmon (blue), coho salmon (red), and steelhead (turquoise) in the Mattole watershed, 1994-95 through 2007-08 seasons (yellow represents unknown species; purple represents undetermined species).

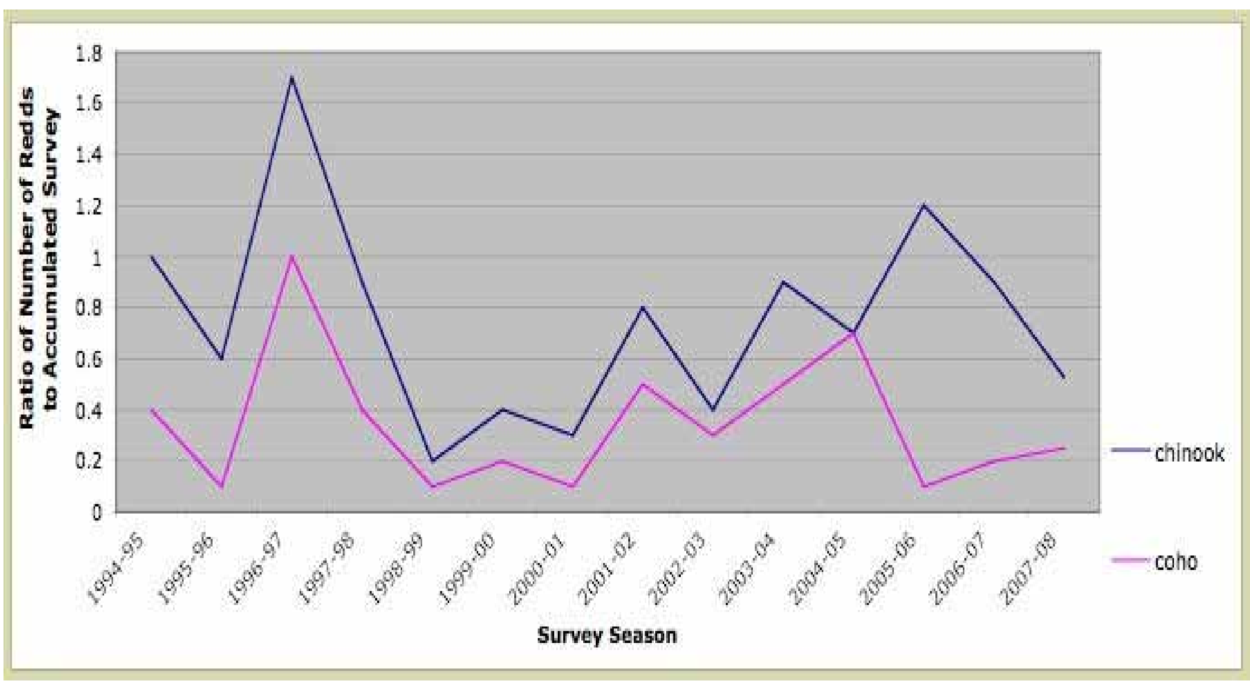

Figure 2: Escapement Index for Chinook salmon (blue) and coho salmon (pink) in the Mattole watershed, 1994-95 through 2007-08 seasons.

The Mattole watershed also contains a population of summer steelhead, which migrate into the watershed in the spring, hold in pools over the summer and spawn in the fall or winter. Snorkel surveys have been conducted annually during the summer months since 1996 to estimate summer steelhead populations. A total of 16 adult summer steelhead (>16 inches in length) and 79 “half-pounders” (12-16 inches in length) were counted during the 2007 surveys. Divers saw fewer adult summer steelhead in 2007 than in 2006 (19) and 2005 (20). In contrast, more “half-pounders” were observed in 2007 in comparison with 2006 (38) or 2005 (34). The number of adults observed per mile of survey effort in 2007 was the second lowest recorded over the past twelve years (0.24 adults per mile). The lowest number of adult sightings per stream mile recorded to date was in 2003 (0.19 adults per mile). Adult observations per mile fell noticeably in 2007 compared to the past three years (an average of 0.32 per mile in 2004-2006). Conversely, the number of “half-pounders” observed per mile of survey effort in 2007 (1.21) was substantially higher than “half-pounders” observed per mile in 2006 (0.59), and 2005 (0.56). The greatest number of adults counted was 45 in 44.9 miles surveyed (0.98 adults per mile) in 1998. The maximum count for “half-pounders” was in 2000; 96 were observed in 32.7 miles surveyed (2.95 per mile).

Table 3: Adult summer steelhead and “half-pounder” counts in the Mattole River and tributaries, 1996-2007.

YEAR	ADULTS	HALF-POUNDERS	MS Miles	Tributary Miles	MILES	Adults (>16") per Mile	"Half-pounders" (12"-16") per Mile
1996	14	36	23.6	1.7	25.3	0.55	1.42
1997	16	19	38.0	1.3	39.3	0.41	0.48
1998	44	85	44.6	0.3	44.9	0.98	1.89
1999	16	88	37.4	1.9	39.3	0.41	2.24
2000	17	96	32.4	0.15	32.55	0.52	2.95
2001	17	40	31.2	0.15	31.35	0.54	1.28
2002	15	22	29.3	0.15	29.45	0.51	0.75
2003	9	21	40.0	6.25	46.25	0.19	0.45
2004	16	44	40.5	6.25	46.75	0.34	0.94
2005	20	34	54.6	6.25	60.85	0.33	0.56
2006	19	38	58.6	6.25	64.85	0.29	0.59
2007	16	79	59.3	6.25	65.55	0.24	1.21

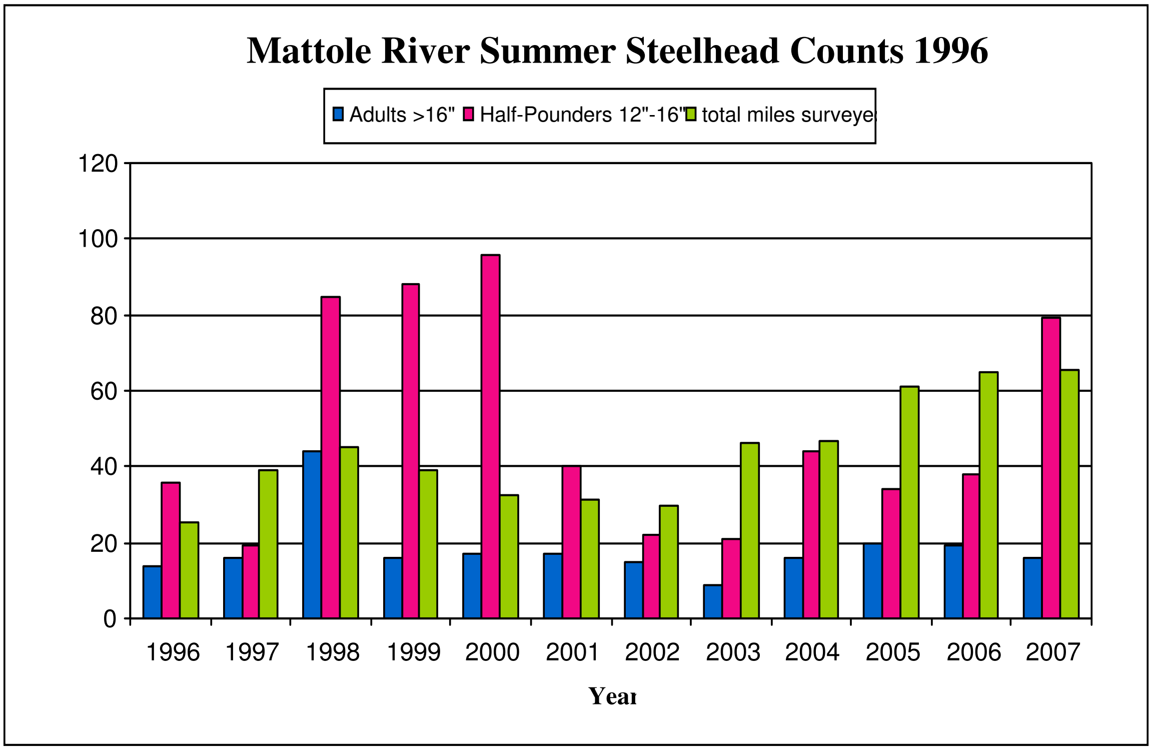

Figure 3: Mattole Salmon Group summer steelhead dive counts. Direct dive observation of adult steelhead (>16"), "half-pounders" (12"-16") and miles surveyed in the summer months, 1996-2007.

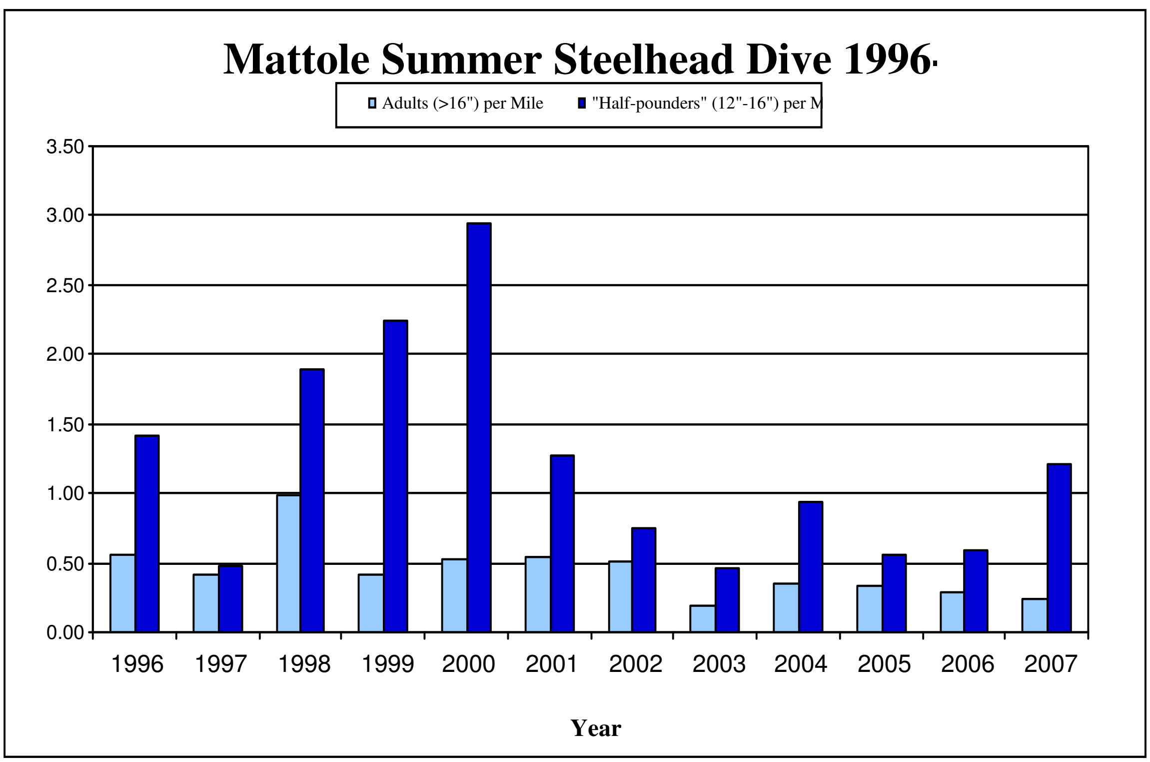

Figure 4. Steelhead per mile observed during MSG Summer Steelhead Dives, 1996-2007.

B. Distribution

i. Juvenile Salmonids

Dive surveys have documented salmonid oversummer distribution since 1991. Spring and fall dives in Mattole tributaries at temperature monitoring locations document juvenile salmonid distribution and oversummer survival in tributaries throughout the watershed. In the mainstem Mattole, juvenile dive surveys are conducted at dissolved oxygen monitoring locations in the upper Mattole, at temperature monitoring locations throughout the river, and in the Mattole estuary. The annual Summer Steelhead Dive also provides data on juvenile salmonid distribution. Surveyors note species presence in reaches spanning nearly the length of the entire mainstem and the lower sections of two of the largest tributaries, Bear (RM 42.8) and Honeydew (RM 26.4) Creeks.

Timing and location of dive surveys influences our knowledge regarding juvenile salmonid distribution. Over the years, snorkel surveys have been conducted in most of the Mattole's salmonid-bearing tributaries in addition to widespread mainstem locations. However, funding and staffing constraints do not allow temperature and dive monitoring in all monitoring locations each year. In addition, it is often impractical to monitor upper, middle and lower stream reaches in each tributary, so it is possible that species present are not observed. Snorkel surveys are in some cases limited by lack of access. Spring rains and resulting flow and turbidity limit commencement of temperature and dive monitoring until May in most years. It is also nearly impossible to verify juvenile salmonid species prior to May due to their small size. Chinook in particular may emigrate from tributary locations before spring dive surveys are conducted. However, considering the number of years monitored and geographic scope of this project, we do have a reliable understanding of juvenile salmonid distribution throughout the Mattole (Figure 5)

Juvenile steelhead are observed throughout the river system. During MSG Summer Steelhead Dives, steelhead have been observed in every reach surveyed in 1996-2007, demonstrating their widespread distribution (Figure 5). Steelhead also inhabit tributaries extensively throughout the watershed. Juvenile steelhead were observed in every tributary where dive surveys were conducted in 2007. Greater tolerance to elevated water temperature (Coates *et al.* 2002, Welsh *et al.* 2001, Barnhart 1986) and diverse life history strategies (Barnhart 1986, Moyle 2002) contribute to their ability to reside in more river miles and habitat areas of the mainstem and greater number of tributaries than the two salmon species.

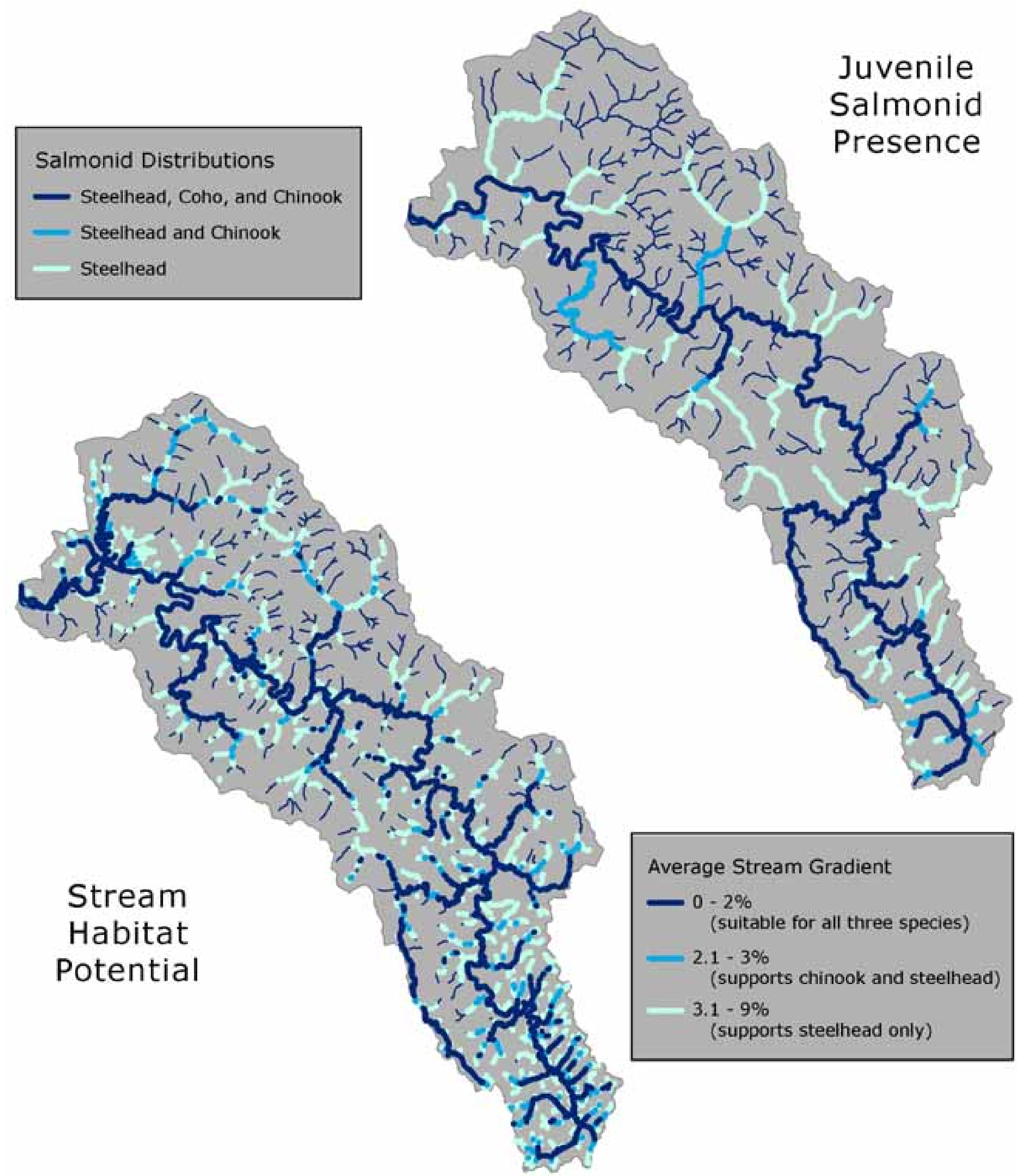

Figure 5: Mattole Watershed Juvenile Salmonid Distribution, determined by MSG dives, 1983-2007.

Juvenile Chinook and coho salmon are also observed throughout the watershed, but they are not as widely distributed, and there is noticeable difference in their distribution. In the mainstem, coho salmon young-of-the-year are observed oversummering almost exclusively in the upper river. Although coho are observed throughout the upper mainstem (upstream of Bridge Creek (RM 52.1)), they are most abundant upstream of Van Arken Creek (RM 54.0). This also coincides with the area of the mainstem where summer water temperatures usually do not exceed the threshold for coho presence, as determined by Welsh *et al.* 2001.

In 2003, the MSG began monitoring dissolved oxygen in the upper headwaters. The MSG's dissolved oxygen monitoring project encompasses many of the large pools in the thermally favorable coho rearing habitat located near the Mattole headwaters in the southern Mattole subbasin. Dives at dissolved oxygen sampling pools in the upper mainstem provide data on abundance and survival of oversummering juvenile coho salmon. Earlier in the summer, juvenile coho salmon in the upper mainstem are relatively abundant and their distribution is fairly widespread. By the fall, snorkel surveyors note declines in the observed population, and the remaining juvenile coho salmon are limited to habitat farther upstream (upstream of RM 54.0). Very small numbers of coho salmon smolts are also observed at the downstream migrant trap in the lower mainstem Mattole, and in the Mattole estuary during the spring.

In recent years (2002-2007), MSG divers have observed juvenile coho in fewer tributary reaches than during dive surveys of the past (1983-2001; Table 1). This may be a reflection of the tendency to survey only lower stream reaches of tributaries in recent years due to funding and access constraints, but is notable nonetheless. While dive surveys by the MSG and HSU students documented 24 tributaries with coho presence in 1983-2001 (50 reaches in 41 tributaries were surveyed, 33 reaches had coho), in 2002-2006, coho were observed in 17 tributaries (23 tributary reaches). Forty reaches in 30 tributaries were surveyed in 2002-2006. In 2007, the most widespread temperature and dive monitoring conducted in recent years, 36 reaches in 35 tributaries were surveyed. Juvenile coho salmon were observed in 10 tributaries (in 10 reaches). Juvenile coho salmon are also more widely distributed in spring than in fall. In 2007, juvenile coho salmon were observed in nine tributaries during spring dives, but only four tributaries in the fall.

Table 4: Salmonid Presence and Average MWAT (Maximum Weekly Average Temperature) by sub-basin determined by MSG Dive Surveys, (1983-2007) and Temperature Monitoring, (2000-2007).

Subbasin Name	River Mile	Years Monitored	1983-2001* Salmonids	2002-2006 Salmonids	2007 Salmonids	Average MWAT
Lower Bear Creek	1+0.3	05, 07	sh, ss	Sh	sh	57.75
Stansberry Creek	1.3+0.1	98-99, 06-07	sh	Sh	sh	59.75
Mill Creek	2.8+0.1	95-07	sh,ss	sh, ss	sh, ss	58.67
Lower North Fork	4.7+~1.0	95-98, 06-07	sh	Sh	sh	70.88
East Mill Creek	5.4+~0.2	03-07	sh	sh, ss	sh	61.95
Clear Creek	6.1+0.2	00-02, 06-07	sh,ss	sh, ss	sh, un	59.70
Conklin Creek	7.8+0.3	95-97, 00, 06-07	sh	Sh	sh	66.92
McGinnis Creek	8.0+0.1	06-07	sh	sh*	sh	65.19
Wild Turkey Creek	12.7+~0.1	05-06	sh	sh	n/a	59.54

Squaw Creek	14.9+0.1	95-99, 05-07	sh,ss,ks	sh, ss, ks	sh*	69.49
Saunders Creek	19.9+0.1	01-02, 06	sh	sh	n/a	63.07
Woods Creek	24.1+0.1	00-02, 06-07	sh,ss	sh, ss	sh, ss	62.03
Upper North Fork	25.5+~1.0	95-00, 06-07	sh,ss,ks	sh	sh	71.56
Oil Creek (tributary to Upper North Fork)	25.5 +~2.0+~0.1	07	n/a	n/a	sh	68.97
Honeydew Creek	26.5+~1.0	95-99, 06-07	sh, ss, ks	sh	sh	67.50
Honeydew Creek (air)	26.5+~1.0	07	"	"	"	68.68
Honeydew Creek (upper)	26.5 + ~2.5	06-07	n/a	n/a	sh	65.47
Honeydew Creek (East Fork)	26.5+~2.5+0 .1	07	n/a	n/a	sh	67.62
Dry Creek	30.4+ ~0.1	00-02	sh	sh	n/a	65.64
Middle Creek	31.3+ ~0.2	00-02, 05	sh	sh	n/a	61.56
Westlund Creek (upper)	31.7+ ~1.2	00-02	sh	sh	n/a	61.60
Westlund Creek (lower)	31.7+ ~.01	98, 00-02	sh	sh	n/a	63.22
Gilham Creek	32.8+~0.1	05, 07	sh	n/a	sh	62.46
Fourmile Creek	34.6	07	sh,ss	n/a	sh, ss	65.08
Sholes Creek	36.6	07	sh, ss	n/a	sh	62.38
Grindstone Creek	39+~0.1	00, 07	sh, ss, ks	n/a	sh	66.29
Mattole Canyon Creek (upper) (deep)	41.1+3.1	01-02	sh, ss, ks	sh	n/a	64.49
Mattole Canyon Creek (upper) (shallow)	41.1+3.1	95-99, 01-02	s	sh	n/a	67.99
Blue Slide Creek	42.0 +~0.1	95-00, 07	sh	n/a	sh	65.94
Bear Creek	42.8+~0.2	95-04, 07	sh, ss, ks	sh, ss, ks	sh, ks	70.72
Bear (air)	42.8+~0.2	00-01, 04	"	"	"	67.08
Bear (us Jewett)	42.8+~2.1	07	n/a	n/a	n/a	66.51
S. Fork Bear	42.8+~6.0	95-97, 07	sh, ks	n/a	sh, ks	60.25
Jewett Creek (tributary to Bear Creek)	42.8+~2.0+~ 0.1	07	n/a	n/a	sh, ks	61.67
Deer Lick Creek	45.9 + ~0.1	07	sh	n/a	sh	61.88
Big Finley Creek	47.4+~0.1	99, 07	sh, ss	n/a	sh, ks	59.80
Eubanks Creek	47.7+~0.1	99-00	sh, ss, ks	n/a	sh	61.71
Bridge Creek (lower)	52.1+~0.1	95-97, 99-00, 02-04, 07	sh, ss, ks	sh, ss	sh	62.04
Bridge (lower) air	52.1+~0.1	02-04	"	"	"	64.92
Robertson Creek	52.1+2.1	02-04	sh, ss	sh, ss	n/a	60.64

(upper Bridge Creek)						
Bridge Creek (west fork)	52.1+2.15	02-04	sh, ks, ss	sh, ss, ks	n/a	58.42
McKee Creek	52.8+~0.1	06-07	sh, ss, ks	n/a	sh, ss, ks	63.34
Van Arken Creek	54+~0.1	95-00, 04, 07	sh, ss	n/a	sh, ss	60.84
Anderson Creek (lower)	55.8+0.06	02-04	sh	Sh	n/a	59.27
Anderson Creek (upper)	55.8+0.35	02-04	sh	Sh	n/a	57.76
Upper Mill Creek (lower)	56.2+0.1	02-04, 07	sh, ss, ks	sh, ss	sh, ks	60.00
Upper Mill Creek (lower) (air)	56.2+0.1	02-04	"	"	"	63.44
Upper Mill Creek (upper)	56.2+1.4	02-04	sh, ss	sh, ss	n/a	58.45
Baker Creek (lower)	57.6+0.01	02-04, 07	sh, ss, ks	sh, ks, ss	sh, ss	59.37
Baker Creek (lower) (air)	57.6+0.01	02-04	"	"	"	64.43
Baker Creek (upper)	57.6+0.95	95-99, 02-04	sh, ss, ks	sh, ss	n/a	59.12
Thompson Creek (lower)	58.4+0.15	00, 02-04,07	sh, ss, ks	sh, ss, ks	sh, ss, ks	61.60
Thompson Creek us Yew (air)	58.4+0.15	04	"	"	"	65.65
Thompson Creek (upper)	58.4+2.3	95-04	sh, ss	sh, ss	n/a	56.96
Thompson Creek (north fork)	58.4+2.2	02-04	sh, ss	sh, ss	n/a	57.78
Yew Creek (lower) (tributary to Thompson Cr)	58.4+0.13	95-00, 02-04, 07	sh, ss	sh, ss	sh, ss	59.80
Yew Creek (upper) (tributary to Thompson Cr)	58.4+0.55	02-04	sh, ss	sh, ss	n/a	60.93
Helen Barnum Creek (lower)	58.7+0.01	02-04, 07	sh, ss	sh, ss	sh	57.43
Helen Barnum Creek (upper)	58.7+0.9	02-04	sh	Sh	n/a	57.51
Lost River (lower)	58.8+0.01	02-04, 07	sh, ss	sh, ss	sh, ss	59.35
Lost River (lower) (air)	58.8+0.01	02-03	"	"	"	62.10
Lost River (upper)	58.8+1.0	95-99, 02-03	sh, ss	sh, ss	n/a	54.15
McNasty Creek	60.8+0.02	02-04	sh, ss	sh, ss	n/a	55.93
McNasty Creek (air)	60.8+0.02	02-04	"	"	n/a	63.34
Ancestor Creek	60.8+0.15	01-04, 07	sh, ss	sh, ss	sh, ss	56.77

*1983-1991 survey presence determined by MSG spawner surveys.

**Definitions of above abbreviations; sh-steelhead, ss-coho salmon, ks-Chinook salmon, un-unknown salmonid, n/a-not assessed, us-upstream, ds-downstream.

Tributaries of the lower Mattole River with documented juvenile coho salmon presence in recent years include Mill Creek (RM 2.8), East Mill Creek (RM 5.4), Clear Creek (RM 6.1), Squaw Creek (RM 14.9), and Woods Creek (RM 24.1). These tributaries have the coolest water temperatures, and have the most presence of riparian cover and pool habitat of the tributaries of the lower Mattole River. In 2007, divers saw coho salmon in only two tributaries in the lower Mattole River, Mill Creek and Woods Creek. Of the coho-bearing streams in the lower Mattole, Mill Creek has the coolest water temperatures and contains arguably the best oversummering habitat for coho and steelhead. The Mill Creek basin is largely protected and contains considerable old-growth forest habitat.

In the middle Mattole, tributaries with historical juvenile coho salmon presence include Fourmile Creek (RM 34.6), Sholes Creek (RM 36.6), Grindstone Creek (RM 39.0), Mattole Canyon Creek (RM 41.1), Bear Creek (RM 42.8). Of these, only Fourmile Creek has had a recent coho salmon sighting (in fall 2007). Coho salmon were also found in the MSG's Bear Creek downstream migrant trap in 2003 and prior years.

Tributaries in the upper Mattole provide important oversummering habitat for juvenile coho salmon, both because they have cooler water temperatures and provide good rearing habitat. In 2007, juvenile coho salmon were observed in McKee Creek (RM 52.8), Van Arken Creek (RM 54.0), Baker Creek (RM 57.6), Thompson Creek (RM 58.4), Yew Creek (a tributary to Thompson Creek, RM 58.4+0.15+0.1), Lost River (RM 58.8), and Ancestor Creek (RM 60.8). Tributaries where historically juvenile coho salmon have been observed but none were identified in 2007 include Big Finley Creek (RM 47.4), Eubanks Creek (RM 47.7), Bridge Creek (RM 52.1), Upper Mill Creek (RM 56.2), and Helen Barnum Creek (RM 58.7).

Juvenile Chinook salmon are observed more frequently in the mainstem Mattole and larger tributaries. In the mainstem, Chinook salmon young-of-the-year are distributed in favorable microhabitats throughout the river, although more are usually found in the upper mainstem. In 2007, Chinook salmon were observed in the upper mainstem (upstream of Bridge Creek at RM 52.1) during snorkel surveys as part of MSG's dissolved oxygen monitoring, in the pool in the Mattole at the confluence of Big Finley Creek (RM 47.4), at the Wingdam (RM 2.9), and in the estuary. During the 2007 Summer Steelhead Dive, juvenile Chinook salmon were observed in the two uppermost mainstem reaches and one reach in the lower mainstem.

Small numbers of juvenile Chinook salmon are observed in the upper mainstem (upstream of Bridge Creek at RM 52.1) throughout the summer in larger pools monitored for water quality, flow, and salmonid presence. Few Chinook salmon are observed in the middle mainstem at any time of year, likely using this area as a migration corridor. In the spring, divers see large numbers of emigrating Chinook salmon in the lower river. In years where the river mouth closes late, most emigrate to the ocean, and few are observed in the river later in the summer. When the river mouth closes early, however, juvenile Chinook salmon are found in the lower mainstem later in the summer, populating cool refuges and the estuary. Few are observed by the fall in either case, indicating many do not survive oversummer in the lower river.

Juvenile Chinook salmon are most often observed in larger, cool tributaries in the Mattole River watershed, although they are sometimes found in small upper tributaries as well. Tributaries where Chinook were observed in 2007 include Ancestor Creek (RM 60.8), Thompson Creek (RM 58.4), Yew Creek (a tributary to Thompson Creek, RM 58.4+0.15+0.1), Upper Mill Creek (RM 56.2), McKee Creek (RM 52.8), Big Finley Creek (RM 47.4), and in Bear Creek (RM 42.8) and its tributaries, South Fork Bear Creek (RM 42.8 + ~6) and Jewett Creek.

Juvenile Chinook salmon are observed in more tributaries in the upper Mattole, and are especially numerous in Thompson Creek (RM 58.4) and Yew Creek (a tributary to Thompson, RM 58.4 +0.15). In addition to the upper Mattole tributaries where Chinook were found in 2007, MSG divers have seen juvenile Chinook salmon in Eubanks Creek (RM 47.7), Bridge Creek (RM 52.1), and Baker Creek (RM 57.6). Juvenile Chinook salmon presence was confirmed in Ancestor Creek for the first time in 2007, although this is not surprising, given the size of the tributary, the cool water temperatures, and its location near the headwaters.

In the middle Mattole watershed, Bear Creek and its tributaries are the only drainage where juvenile Chinook salmon are consistently observed. Historically, MSG divers have also located juvenile Chinook salmon in Mattole Canyon Creek (RM 41.1) and Grindstone Creek (RM 39.0), although they have not been seen in recent years. In the lower Mattole, juvenile Chinook salmon are often observed in Squaw Creek (RM 14.9). In the past, juvenile Chinook salmon have also been present in Honeydew Creek (RM 26.4) and the Upper North Fork (RM 25.5), although recent dives have not confirmed their presence in these drainages.

The Upper and Lower North Fork, Bear Creek, and Honeydew Creek are the largest tributaries in the Mattole. In the Lower North Fork, historically, only steelhead were known to reside. However, 2008 was the first year the MSG conducted downstream migrant trapping on the Lower North Fork, and juvenile Chinook salmon were found emigrating from the watershed. The Upper North Fork, Bear Creek, and Honeydew Creek have historically supported steelhead, coho salmon, and Chinook salmon populations. Dive surveys since 2002, however, have only found steelhead in both upper and lower sections of Honeydew Creek and in the Upper North Fork. In Bear Creek, juvenile Chinook salmon were observed in 2007.

ii. Adult Salmonids

The MSG has conducted spawner surveys annually since the 1981-82 season. These surveys are the primary source of information on the adult salmonid populations in the watershed. The data collected are intended primarily to track long-term trends in escapement and spawner distribution for Chinook salmon and coho salmon. Some data is incidentally collected on steelhead /rainbow trout. The data also provides insights into run timing, spatial distribution, ratio of males to females, ratio of jacks/chubs to full adults, ratios of MSG propagated and/or reared fish to wild fish, as well as the individual size and condition of Mattole salmonids.

Surveys are conducted by wading, canoeing or snorkeling specified stream segments one or more times during the salmon spawning season generally late November through late January. Survey timing and location is determined by the interplay of weather/flow events and fish presence. For example, the mouth of the Mattole does not usually open to the ocean until there is a sufficiently intense rainfall to produce a significant flow rise from summer conditions. This is generally about three inches of rain within a few days time. As a result, the spawning run and surveys cannot start until after this event which has been recorded to occur anytime from mid-September to December. Subsequent flow events and timing determine the fish's ability to move upriver over various low-flow barriers. The clarity of the water and hence the surveyor's ability to see redds and fish are also determined by flow levels and timing.

Past survey data indicates that the distribution and timing of salmonid spawning varies by species. Chinook salmon enter the river first, then migrate upstream as subsequent rains allow. Chinook spawners are observed entering the river shortly after the mouth opens in the fall and are often observed holding in pools in the lower river, waiting for adequate flows that allow them passage upstream. Mattole Chinook salmon usually spawn from late November through early January, but the exact timing is dependent on weather and environmental conditions.

Location of spawning is influenced by the date of mouth opening and the timing of subsequent rains. In years with adequate rain, many will spawn in the southern subbasin near the headwaters, and in larger tributaries like Bear Creek (RM 42.8). In drier years, if rains are too meager to allow access to the headwaters and tributaries, Chinook have been observed spawning lower in the river system. However, survival of eggs and fry here is believed to be lower than in the headwaters. Spawning gravels in the lower and middle river are more impacted by fine sediment, and large winter flows are more likely to bury or scour out the redds before the fry are able to emerge. Emergent fry in the lower and middle river are also subject to less than ideal conditions for overwinter survival due to higher likelihood of predation by adult steelhead, lack of cover and particularly prolonged turbidity that inhibits feeding and growth.

Coho salmon also enter the Mattole River shortly after the mouth opens from fall rains. Their river entry and spawning overlaps with Chinook, but lasts later, usually until late January or early February. Spawning coho are observed in many of the upriver (southern subbasin) tributaries and a few tributaries in the middle and lower river. In the mainstem, spawning coho are usually observed very near the headwaters, although they are sometimes observed en route as well.

Less is known about steelhead spawning, as MSG's spawner survey program has been focused on salmon due to funding constraints. Most adult steelhead in the Mattole spawn later than the two salmon species, typically starting in early January, with the peak extending into March with some spawning even as late as June 22nd during wet springs. The remnant summer steelhead population however spawns earlier than all the other species, digging redds in the very first flows that open the mouth for the other runs to enter the river. Distribution of steelhead spawning appears wider than that of the two salmon species according to the observations that have been made during past spawning surveys as well as dive surveys, trapping, etc.

Since 1996, the MSG's annual Summer Steelhead Dive has provided critical information about the habitat distribution of adult summer steelhead (>16") throughout the Mattole watershed. Upstream of McKee Creek (RM 42.8), near the Mattole headwaters, few summer steelhead are observed, likely due to the small size of the mainstem and hence lack of deep pool habitat, as well as recent issues with low flow during the summer months. Consistently, the greatest number of summer steelhead per mile have been observed from McKee Creek (RM 52.8) to Dry Creek (RM 30.4). Cooler summer water temperatures here (in comparison with the lower mainstem) and presence of deep pools in the upper and middle river represent the best oversummering habitat for adult steelhead in the Mattole. Less frequently, summer steelhead are observed in cool, favorable habitats such as deep pools and areas with instream cover such as large wood and boulders in the lower river. Summer steelhead also oversummer in Bear Creek and Honeydew Creek, the third and fourth largest tributaries to the Mattole, respectively.

C. Habitat

i. Migratory Habitat

The Mattole is blessed with the lack of any major dams, and few significant natural barriers. Human-caused barriers have consisted almost entirely of road culverts in tributaries. There are also a small number of small dams in tributaries used to store and divert water. Road culverts have been the focus of widespread restoration/replacement efforts in past years and fewer exist as barriers. In particular, there are almost no culverts left in the anadromous reaches of the upper river. This effort should be continued and especially expanded to more mid and lower river tributaries in the near future. The small dams have been less addressed to date, although one in the lower river tributary (East Mill Creek) was removed in summer2008. Fortunately, existing dams are almost all located in the upper ends of anadromous reaches (East Mill Creek, Buck/Sinkyone Creek, Pond Creek), thus having relatively little impact as migratory barriers. However, efforts to remove them have been more difficult than culverts as a result of few practical options to replace the dam's function in providing water during summer. The only small dam located low in a tributary (Thompson Creek) has been observed not to function as a significant barrier to adults migrating upstream due to the removal of flashboards prior to significant fall rains. Depending on the timing of flashboard placement in spring, this dam may function as a barrier to upstream migration of juveniles. It is hoped that the institutional water users program recently launched by Sanctuary Forest, Inc. will provide a way to address the Thompson Creek summer dam.

There are two key natural migration barriers in the mainstem Mattole, both of which only function as barriers to upstream migration to adults during low flows and neither of which serve as downstream migration barriers at any time. The first is a cascade just upstream of Honeydew resulting from a massive landslide which created a temporary dam in 1983 and is now a high-gradient boulder field. At moderate to high flows, salmonids routinely cross this barrier on their upmigrations. Similarly, there is a natural gorge of high gradient and large boulders that functions in the same manner located in the vicinity of Nooning Creek.

Similar naturally occurring high-gradient gorges occur in numerous tributaries and function as low-flow barriers. Notable examples include Bear Creek above Jewett Creek, the lower section of Eubanks Creek, Squaw Creek, and Anderson Creek.
The Mattole estuary functions as a migration corridor as well as a critical point of transition from saltwater to freshwater for immigrating and emigrating salmonids. While adult summer steelhead are occasionally observed in deeper sections during the summer months, adult spawners are rarely seen, migrating through only briefly on their way upstream at times when the estuary is unsurveyable due to high flows. Juvenile salmonids that emigrate to the ocean may freely rear in the estuary for a short or extended period prior to ocean entry, or rear in the lagoon upon emigrating after mouth closure by sandbar formation (Shapovalov and Taft 1954, Young 1987, Smith 1990, Busby 1991, Zedonis 1992, Bond 2006). Numerous studies conducted over several decades have demonstrated the importance of these natural basin features in providing valuable habitat to a variety of salmonids that include steelhead, Chinook, and coho salmon (Shapovalov and Taft 1954, Reimers 1973, Young 1987, Smith 1990, Busby 1991, Zedonis 1992, Bond 2006).

The Mattole River estuary transitions to a lagoon during late spring and early summer in most years, forming a barrier to ocean migration. Lagoon formation and its permanency of closure are dependent upon a number of physical processes which include river flow, long-shore ocean currents and wind waves, substrata type and abundance, coastline shape, and channel width and volume (Barnes 1984, Smith 1990). Based on 24 of the last 25 years for which records have been maintained, the dates of permanent lagoon formation range from May 26 (1987) to September 8 (1990) and the median date of closure is approximately July 7 (Table 2). A common attribute of the historic data set is that lagoon formation occurs when flow of the Mattole River is less than 140 cubic feet per second (cfs) at the USGS Petrolia gaging station. The earliest closure on record in the last 25 years, May 26, 1987, coincided with the same year that Busby *et al.* (1988) documented nearly complete mortality of 75,000 to 145,000 juvenile Chinook salmon rearing in the lagoon over a two-month period.

Table 5: Date of Mattole River Mouth Closure, Close/Open Cycles, and Number of Days Closed, 1981-2007.

	Date of Initial Mouth Closure	Discharge (cfs) at Initial Mouth Closure	Number of Close/Open Cycles	Total No. of Days Closed	Approx. Date of Final Sandbar Breaching (Month/Day)
Year	(month/day)	(USGS Petrolia gage)*			
1981	?	?	?	?	9/27
1982	early to mid-July	~80	?	~120	~10/31

1983	*mouth did not close in 1983*			0	–
1984	early July	~100	1	~92	10/11
1985	6/28	65	1	~115	~10/22
1986	6/23	108	2	~126	~10/30
1987	5/26	133	1	~135	~10/8
1988	7/21	63	1	104	11/3
1989	8/4	44	1	79	10/23
1990	9/8	49	1	53	10/31
1991	7/4	67	6	53	11/17
1992	6/11	104	2	97	10/1
1993	8/10	79	2	96	11/29
1994	7/8	89	1	120	11/5
1995	7/16	102	2	138	12/1
1996	7/9	115	3	131	11/17
1997	6/21	122	2	103	10/2
1998	7/21	77	2+	109	11/7
1999	6/24	98	2+	126	10/28
2000	6/17	55	2	169	12/12
2001	6/3	99	2	119	10/31
2002	6/13	108	2	156	12/13
2003	8/8	55	3	91	12/1
2004	6/27	77	2+	146	12/7
2005	8/16	88	1	61	10/15
2006	7/23	68	1	132	11/3
2007	7/4	62	2+	78	11/13

*2000-2007 data compiled by Maureen Roche and Amy Baier
**1999 and prior data from MSG's Five-Year Management Plan (2000).

In addition to natural barriers to outmigrants, seasonal drying of the mainstem and tributaries restricts salmonids from migrating to more favorable areas during the summer months. Aggradation at mouths of cool water tributaries presents a barrier to juvenile salmonids seeking refuge from unfavorable temperatures in the mainstem. In addition, some outmigrants may be trapped in tributaries and unable to emigrate to the ocean for the duration of the summer. In most years, however, spring flows allow emigration for the duration of time the river mouth is open, so these low-flow barriers probably do not create much of a difference.

ii. Spawning Habitat

Most of the Mattole and its tributaries are low-gradient gravel and cobble substrate streams that provide excellent spawning habitat for anadromous fishes. It should be noted that many of the tributaries of the Western subbasin are high gradient for their entire length due to the rapid uplift of the King Range and as a result provide only steelhead spawning habitat. Spawning habitat in some tributaries, particularly in the Northern and Eastern subbasins, are negatively impacted by fine sediment which fills the spaces between larger particles in riffles and prevents water and oxygen transport to developing eggs in redds. This fine sediment is often a product of residual damage done in the early days of the logging boom or of current improper road maintenance and construction. It also results from landslide activity and more erodible clay soils, hence the prevalence of this problem in the Northern and Eastern subbasins. Of particular concern is use of unrocked dirt roads and stream crossings during the winter and spring spawning seasons. Ongoing road upgrade and landowner education programs are aimed at addressing this issue and will hopefully be expanding soon into the Eastern and Northern subbasins. One interesting note on this is that over the past ten years, and particularly since the inception of road upgrades and decommissioning in the headwaters, the upper Mattole mainstem has been observed to clear up after storms much more quickly than it did from the 1950s through the mid-1990s. This indicates much lower amounts of fine sediment entering the watercourse. In addition, the higher gradient mainstem reach below the upper mainstem, from Nooning Creek down to Deer Lick Creek has been scoured out, with pools becoming much deeper and substrate particle size increasing.

Salmonid spawning predominantly takes place in the upper mainstem and upper tributaries with very little spawning activity observed in lower river tributaries and the lower mainstem. Thus, coverage is predominantly of the mainstem and upper river tributaries, with less coverage of mid and lower river tributaries and none in the Northern subbasin. This is the unfortunate result of limited private land access in those areas. However, access was granted to operate a downstream migrant trap in the Lower North Fork Mattole in spring 2008. Trapping operations revealed juvenile chinook and steelhead emigrating from that portion of the Northern subbasin, thus providing initial documentation of Chinook spawning in this drainage, the largest of all Mattole tributaries.

Rainfall and the resulting flows vary in their timing and size each year resulting in shifts in spawning habitat usage. In low rainfall years when adult salmon find themselves trapped by low flows in the lower mainstem for extended periods, spawning will occur there, while in high-flow years salmon are observed spawning high in the watershed while the lower reaches are unsurveyable due to high flows and high levels of turbidity. Given that spawning locations are observed to be primarily determined by the timing and size of flows, and the low rates of redd superimposition during spawner surveys, it seems clear that there is far more suitable spawning habitat available than there are spawning adults to utilize it. As a result, spawning habitat is no longer considered a limiting factor in the Mattole.

iii. Rearing Habitat

Rearing habitat for juvenile salmonids in the Mattole includes the mainstem, from the headwaters to the lower river, the estuary/lagoon, and tributaries. Summertime water temperatures represent the most widespread limit to salmonid over-summering in the Mattole, affecting much of the watershed.

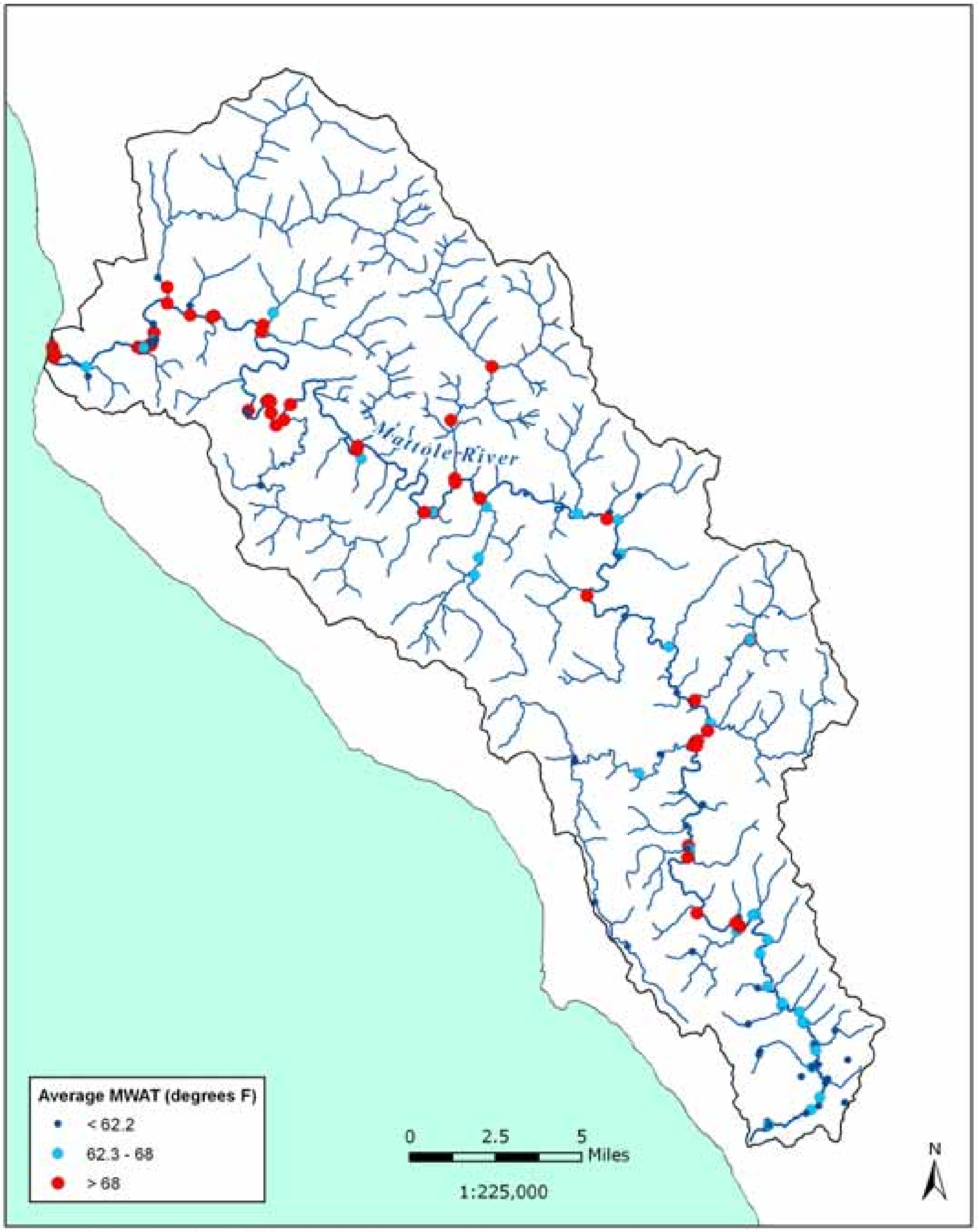

Figure 5. 2000-2007 Average MWAT (Maximum Weekly Average Temperature) at MSG Temperature Monitoring Locations throughout the Mattole Watershed.

Threshold criteria used to evaluate thermally suitable habitat in the mainstem Mattole River and tributaries includes measures of both chronic and acute stress. Maximum weekly average temperature (MWAT) and maximum weekly maximum temperature (MWMT) are used to evaluate chronic stress due to water temperature exposure. MWAT is determined by the highest average of mean daily temperatures of any 7-day period, and MWMT is determined by the highest average of maximum daily temperatures over any 7-day period. Maximum temperatures are used to evaluate acute thermal stress during short-term high temperature exposure.

The upper Mattole provides the majority of thermally suitable mainstem oversummering habitat for juvenile salmonids (Figure 5). Water temperatures in the upper river are significantly cooler than in the lower mainstem. In addition, there are numerous bedrock pools and habitat complexity provided by boulders and large wood. Despite being substantially cooler than the rest of the river, temperatures above or near juvenile salmonid MWAT and MWMT thresholds indicates oversummering salmonids in some downstream areas of the upper mainstem experience stress due to chronic exposure to warmer than optimal rearing temperatures. Some locations in the upper mainstem, especially upstream of RM 54.0, show suitable temperatures for juvenile survival and growth throughout the summer. Only the uppermost temperature monitoring locations have suitable summer thermal habitat for juvenile coho; more areas are thermally suitable for steelhead survival due to their greater temperature tolerance.

Despite favorable temperatures in the uppermost mainstem, issues with low-flow have depleted available habitat in the coolest areas of the mainstem. In recent years, many of the coolest areas of the upper mainstem have dried to a series of disconnected pools. Dissolved oxygen monitoring, in conjunction with dive surveys at critical areas in the upper mainstem, have provided some insight into water quality issues at low flows. In upper locations which experienced the lowest flows due to close proximity to the headwaters, juvenile coho and Chinook salmon were observed earlier in the season but not later when flows were minimal or largely subsurface.

Dissolved oxygen levels and pH measured in the summer of 2007 remained within favorable ranges for juvenile salmonid survival, however dissolved oxygen has been shown as a stressor in certain areas and certain years. It is important to note that a July rain event in 2007 and an unusually cloudy late summer resulted in greater than usual later summer flow in the upper mainstem in comparison to recent years. In years when flow has been extremely low, fatal dissolved oxygen levels have been recorded, resulting in impaired growth for rearing juvenile salmonids, and the death of estimated thousands of juvenile salmonids in 2002. In this extremely dry year, a minimum dissolved oxygen reading of 0.2 mg/L was recorded when the upper mainstem dried completely to a series of disconnected pools.

In 2006, MSG staff measured dissolved oxygen levels in low-flow monitoring locations once a month from late July to late September. An alarming minimum of 0.78 mg/L was recorded on 9/28/06 in the 1st pool upstream of the confluence of the Mattole and Lost River and Helen Barnum Creek (RM 58.7). While the mean of D.O. measurements on 7/28/06 was 8.14 mg/L, by 9/28/06 the mean of D.O. measurements had fallen to 5.77 mg/L below the D.O. threshold considered to impair juvenile salmonid growth and survival (< 6 mg/L, EPA 1986). Low flow in early summer 2008 points to a drier year which almost certainly will result in necessary rescue of juvenile salmonids in low-flow areas, or death of substantial numbers will occur.

Suitable rearing habitat in the upper mainstem is essential to the survival of oversummering juvenile salmonid species in the Mattole watershed. Efforts to promote summertime water conservation and fish rescue in years of low-flow are important to maintain and enhance juvenile coho and Chinook salmon populations. Water conservation provides higher summer flows by reducing withdrawals during peak heat and evaporation. Water storage in large tanks is another method being promoted to increase summertime flows. Capturing water during the winter rains and storing it for oversummer use in large tanks results in less impact upon fish habitat in the summer and contributes to better summertime flows. With increased summer flow, dissolved oxygen is higher and more favorable for oversummering salmonids. In the worst years, however, fish rescue provides the only viable option for ensuring the survival of oversummering juvenile coho and Chinook salmon.

Limited juvenile salmonid rearing habitat exists in the middle and lower mainstem Mattole due to a variety of factors including aggradation, riparian dysfunction, and both acute and chronic temperature stressors. Temperatures recorded in these areas suggest a lack of suitable thermal habitat for all species of juvenile salmonids in the mainstem downstream of Bridge Creek (RM 52.1). Downstream of Big Finley Creek at RM 47.4, maximum temperatures recorded are higher, often above the short-term lethal limit for juvenile salmonids (>75.0°F, Brett 1952). Juvenile salmonid survival is compromised by exposure to lethal temperatures and/or decreased growth rates due to high metabolic demands at higher water temperatures. Sites in the lower mainstem with maximum temperatures below 75.0°F (the threshold for short-term maximum temperature survival) are located in thermal refugia such as stratified pools, cold seeps or cool-water tributaries, all of which are essential for salmonid survival in the lower and middle Mattole over the summer months.

Maximum weekly average temperatures (MWAT) during summer 2007 at mainstem Mattole temperature monitoring sites downstream of river mile 47.4 indicated a lack of favorable oversummering habitat for all species of juvenile salmonids. Maximum Weekly Average Temperatures in fourteen of sixteen sites in the middle and lower mainstem exceeded threshold temperatures for both juvenile coho and steelhead presence (>63.0-66.0°F MWAT, Coates *et al.* 2002). MWMTs and MWATs above threshold temperatures suggest juvenile salmonids are unlikely to persist in the mainstem downstream of river mile 47.4 due to chronic temperature stress and indicate the importance of thermal refugia and tributaries as oversummering habitat.

Historically, the Mattole estuary/lagoon provided deep pools and favorable oversummering habitat for juvenile salmonids. Due to channel aggradation and almost complete absence of riparian cover, deep pools or any sort of favorable habitat or complexity, the estuary/lagoon is no longer viable oversummering habitat for Chinook salmon. The impaired Mattole estuary/lagoon has been determined a major limiting factor to recovery of salmonid populations in the basin (MRC 1995).

Studies conducted in the Mattole lagoon suggest that lagoon rearing may be hindering the recovery of Chinook salmon (Downie *et al.,* 2002). Research conducted by HSU graduate students in the 1980s and more recent MSG estuary monitoring indicate

Chinook salmon juveniles that migrate downstream late relative to lagoon formation experience high mortality. Suggested causes of past high mortalities in the lagoon include high water temperatures (MRC 1995) and exceeding the carrying capacity in terms of food availability when the lagoon formed in mid-May and mid-June (Busby and Barnhart 1995). In contrast, when lagoon formation occurs late relative to emigration of juvenile Chinook, such as after mid-July, few Chinook salmon are typically found in the lagoon (Zedonis 1992, MRC 1995, Downie *et al.* 2002). Data from the DSMT suggest when juvenile Chinook salmon do emigrate to the ocean prior to mouth closure, it is at a substandard size for optimum ocean survival (MSG 2007, Reimers 1973).

The MSG in cooperation with the USFWS initiated the first continuous multi-parameter water quality investigations using datasondes in the Mattole estuary/lagoon in summer of 2006. Concurrent dive surveys monitored oversummer salmonid utilization of six different areas of the estuary.

In the summer of 2007, a situation developed for which there was no documented precedent. An unseasonable rain approaching a magnitude of one inch fell throughout the watershed on July 18, 2007. On July 25, 2007, MSG divers noted an entirely unexpected phenomenon: over 17,000 juvenile Chinook salmon were observed in the estuary. Prior to this date, MSG divers in the Mattole estuary had only observed between 3,000 and 6,000 Chinook in the entire estuary during each biweekly survey. Subsequent dive surveys in the lagoon confirmed a nearly a complete die-off of the juvenile Chinook salmon observed on July 25th, 2007. By the last dive (October 2nd), prior to mouth opening, only one Chinook was observed in the estuary, documenting a complete die-off of a significant portion of the 2007 juvenile Chinook salmon year class. Declines of salmonid populations in the lagoon have been documented by MSG divers and HSU students in past years, but none were so well documented by frequent dive observation as the event in summer of 2007.

Water quality monitoring that occurred in the Mattole River estuary/lagoon in 2007 recorded variations in water quality that may be limiting survival of salmonids in the lagoon. Recordings of dissolved oxygen and pH in the estuary indicate these water quality parameters were not likely an acute threat to salmonid survival in summer of 2007. pH levels recorded were usually within thresholds determined by the North Coast RWQCB (1994) to be suitable for juvenile salmonids, exceeding the upper threshold in the upper lagoon only infrequently. Dissolved oxygen concentrations were usually above slight and severe production impairment thresholds determined by EPA (1986), except for short periods just prior and subsequent to mouth closure.

Because salmonids are exposed to all water quality parameters at once, effects may be cumulative. For example, salmonids were exposed to pH above the upper threshold in mid-September though October, during a time when they were likely in poor condition due to reduced feeding and metabolic demands of rearing in temperatures above the positive growth threshold since July. In addition, daily fluctuations of water quality parameters are an added stressor since greater variability causes more stress to salmonids than gradual changes over a time period.

Water temperature is perhaps one of the most important parameters to assess in determining the suitability of the Mattole River lagoon for rearing salmonids. Water temperature influences juvenile salmonid growth, competition among species, and vulnerability to parasites, diseases and pollutants (Armour 1991). Weekly average temperatures recorded in 2007 throughout the estuary/lagoon suggest thermal conditions were sub-optimal for the positive growth and rearing of juvenile salmonids, especially following river mouth closure. Although MWATs in both the upper and lower estuary/lagoon were not suitable for positive growth of juvenile salmonids, the data support the conjecture that salmonid rearing conditions in the lower lagoon were likely better than in the upper portions of the lagoon.

We have learned that water quality in the estuary/lagoon and related factors such as abundance of food and habitat is not sufficient to support large numbers of oversummering juvenile Chinook salmon. Steelhead seem to fare better, perhaps due to their greater tolerance for warm water temperatures and overall resilience. A management plan involving rescue of significant numbers of Chinook in years they are present in the lagoon in large numbers is essential for the species survival to mitigate for such a large loss in the oversummering juvenile Chinook salmon population.

iv. The Ocean

The ocean provides an important source of marine-derived nitrogen, phosphorous, and other nutrients to river systems in the form of returning spawning anadromous fishes (Gresh *et al*. 2000). Gresh *et al*. reported an historic decrease of 93-94% over the past century of marine-derived nutrients reaching coastal streams and watersheds in the form of spawning salmonids. In the 2007-08 spawning season, coastal California experienced a 73% decline in the number of returning coho salmon (MacFarlane *et al.* 2008), as well as an approximately 70% decrease (since 2004) in spawning Chinook in the Central Valley (Fishlinks 2008). This has led many researchers to believe that poor ocean conditions, such as low productivity, are the primary cause of these low numbers of returning salmon (MacFarlane *et al.* 2008; Fishlink 2008). In addition, the transition from riverine habitat to oceanic waters is one of the most physiologically demanding life phases of juvenile salmonids, and necessitates a larger body size and condition for survival through this transition. Extended rearing in an impaired estuary/lagoon system only compounds the stress of switching from a freshwater to saltwater life.

2. Priority Issues, Goals, and Management Strategies

A. Management Strategies

Strategy 1: Identify limiting factors on stream conditions

The following are the areas where we will focus to determine the presence and extent of non-properly functioning habitat conditions on salmonids. Monitoring water temperature, dissolved oxygen, and flow will indicate where suitable water quality and quantity for salmonid habitat exists and clarify the relationship of water quality factors to salmonid distribution and survival. Sediment monitoring will provide information on recovering drainages and indicate where sediment reduction work would be best aimed. Aquatic macroinvertebrate monitoring will help clarify food availability and habitat health. These factors affecting habitat will be analyzed and evaluated to determine which factors limit Mattole salmonid populations and where the limits are most constraining. Critical information on stream conditions will allow restoration activities to be directed most effectively and efficiently.

Strategy 1.1: Identify areas in specific project sites, in conjunction with the Riparian Ecosystem Program of the MRC, in tributaries and reaches that are characterized by high temperature, low water, deficient cover and lack of complex habitat.

Strategy 1.2: Identify sediment effects on habitat conditions in the form of turbidity, embeddedness, sediment transport, pool depth, and channel aggradation.

Strategy 1.3: Identify critical habitat reaches where water quantity affects functioning habitat conditions by 2015

Strategy 2: Reduce the impact of limiting factors on salmonids

The MSG will implement strategies to ameliorate conditions limiting salmonid distribution and survival. Lack of habitat complexity will be addressed through habitat improvements, including placement of large wood structures throughout the watershed. Riparian planting will contribute to better cover in fish-bearing tributaries where it is lacking. Improvement of estuarine habitat will also integrate large wood structures and riparian planting. Barrier removal in cool-water tributaries will increase access to favorable habitat for both adult and juvenile salmonids. Community outreach and education will promote landowners to integrate consideration of salmonids into their land management, protecting access to good habitat and leading toward better future habitat. Water conservation and storage will contribute to better summertime flows and result in improved water quality in crucial headwaters rearing habitat. Detection and eradication of invasives will protect aquatic systems from habitat degradation. In times of imminent death to salmonids, rearing salmonids until limiting factors improve will be implemented as an emergency option.

Strategy 3: Create a long-term monitoring program to measure trends in water quality, water quantity, and salmonid population response

Monitoring Mattole salmonids requires a long-term approach. Current monitoring programs, including downstream migrant trapping, dive observation, temperature and dissolved oxygen monitoring, estuarine monitoring, and spawner surveys, will continue to provide valuable information on salmonid abundance, distribution, and survival. In addition, integrating the best available scientific methodology that is practical to monitor salmonids will be of the utmost importance when studying Mattole populations. Identification and quantification of limiting factors affecting each life-history stage will be addressed by the implementation of this new long-term monitoring plan. Pre- and post-project monitoring of restoration projects will allow analysis of current restoration strategies and adaptive response. All of the milestones below will be assessed throughout the life of the plan and beyond.

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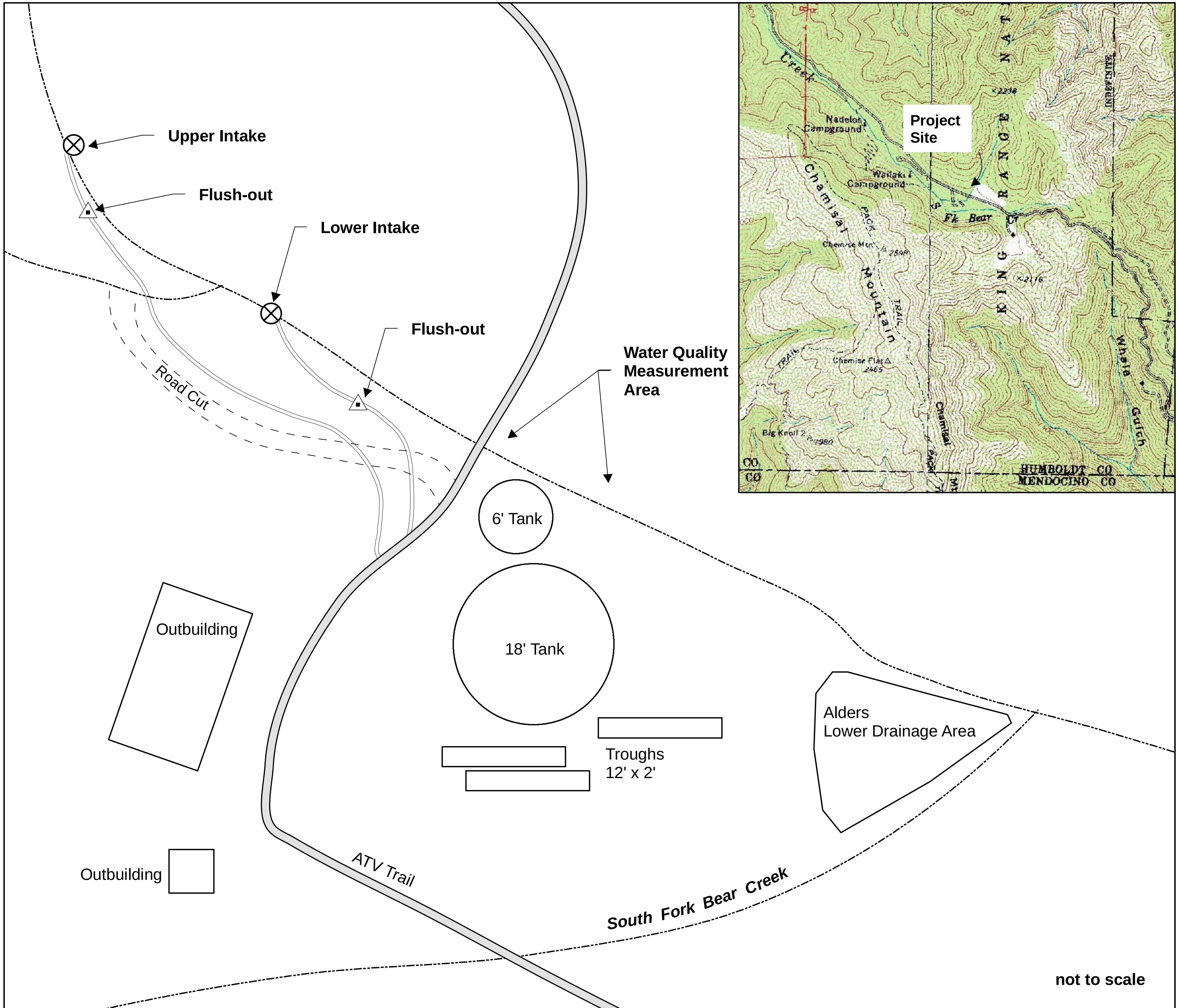

Mattole
Integrated Watershed
Management Initiative

Mattole Coho Recovery Program

Coho Rearing Site
Preliminary Plan

WEST COAST WATERSHED

Riparian Ecosystem Restoration

Number 7 in the
2009 State of the Mattole Watershed Series

Companion to the Mattole Integrated Coastal Watershed Management Plan

Mattole River and Range Partnership

Mattole Restoration Council
Mattole Salmon Group
Sanctuary Forest

August 31, 2009

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1. Current Conditions

A. Riparian forests and stream ecosystems

Riparian forests play a key role in structuring stream ecosystems and processes. Creekside trees moderate stream temperatures through shade and microclimatic effects, influence nutrient cycling through litter and wood inputs, stabilize streambanks, and capture debris and sediment at high flows. Dead wood has an equally large influence on streams in forested ecosystems, influencing sediment storage and routing, channel incision, and instream channel complexity, with specific effects varying depending on channel and valley characteristics and channel size (Naiman et al., 2002, Montgomery et al., 2003). Recently there has been increased focus amongst researchers and restorationists on the ecological role of instream wood — this may be particularly important to improving salmonid habitat in the Mattole, and accordingly a more in-depth review is offered below.

In steep streams in confined valleys (generally headwaters streams) instream wood can be responsible for the development of a stepped channel profile, thereby greatly increasing sediment storage capacity, and can also decrease the runout distance and thus potential destructiveness of debris flows (May, 2007). In lower-gradient channels, wood can force strong spatial variability in sediment grain size deposition, encourage deposition of sediment in bars and terraces, and provide sheltered microsites for the recolonization of riparian vegetation (Naiman et al., 2002, Montgomery et al., 2003).

Wood can play a key role in the formation of pools in moderate gradient (1-5%) gravel and cobble-bedded channels (Beechie and Sibley, 1997, Beechie and Sibley, 2005), supplying obstructions that force pool-forming scour (Buffington et al., 2002). Instream wood tends to increase the complexity of in-channel habitat, providing salmonids cover from predators and refuges from high flows. Channel complexity can also play a key role in increasing hyporheic exchange, a major factor in nutrient cycles and in moderating stream temperatures (Poole and Berman, 2001.)

The amount of instream wood present in a reach at any given time is governed by the amount of wood that enters the stream through tree fall, bank erosion, and mass wasting, and the rate at which wood is exported through fluvial transport or decay (Benda and Sias, 2003). Tree fall occurs as a result of windthrow or mortality. Fire regime and stand age (i.e., chance of density dependent mortality) play roles in determining the input of wood to the channel through tree fall. Steep hillslopes (>40%) may substantially increase the chance that trees fall downslope, hence into the stream (1.5-2.4 times the amount of random treefall) (Sobota et al., 2006).

Steeper more highly dissected watersheds generally have a greater relative contribution of wood from upslope sources delivered to the channel via debris flows and slides (Reeves et al., 2003, Benda, 2004). The ratio of wood input as a result of bank erosion is higher in unconfined channel reaches on alluvial rivers with erodible banks (Martin and Benda, 2001).

The chance that a piece will be transported is a function of the size of the piece and the size of the stream channel. In headwater streams, wood tends to be arranged more randomly, either singly or in jams resulting from debris flow deposition; proceeding downstream, wood is more likely to be organized into jams, due to the greater transport capacity of the stream (Montgomery et al., 2003, Reentmaster, 2004). Log jams may play an ecological role disproportionate to their occurrence, providing important habitat for juvenile salmonids during low-flow periods and winter (Reeves et al., 2003). The abundance of "key pieces," those large enough to form log jams, can greatly influence the retention of wood in a stream system (Montgomery et al., 2003).

While many researchers have contended that the influence and abundance of large wood on channel morphology decreases in large rivers, recent research in the Pacific Northwest has revealed that this may be largely due to historical stream cleaning, and the contemporary lack of pieces large enough to form jams in large river systems. Even in systems where the bankfull width is greater than potential tree height, large log jams can form stable hard points that exert a significant effect on channel morphology, encouraging scour and deposition, overbank flow, and maintaining side channels (Montgomery et al., 2003).

B. Historical and current riparian conditions in the Mattole

Historically a complex canopy of hardwoods and conifers dominated riparian vegetation along most tributaries and the mainstem of the Mattole River. For a more in-depth discussion of historical riparian vegetation and contemporary land-use impacts, please see Chapter 7, Riparian Restoration, in the Mattole Watershed Plan (MRC 2005).

Figure IV-4.1: Mattole Canyon Creek: High sediment loads, poor conditions for natural establishment of riparian vegetation.

While old-growth forest certainly did not occur along every stream mile in the Mattole at all times, mature riparian vegetation provided shade and inputs of organic debris critical to the maintenance of favorable salmonid habitat throughout a large percentage of the watershed at any one time. Following unprecedented logging across the watershed and the 1955 and '64 flood events, aerial photographs from 1965 show canopy removal across much of the Mattole's riparian forests, and highly aggraded channels. Natural recovery and restoration efforts have greatly improved riparian conditions in the last 20-30 years, but most of the Mattole's riparian stands are composed of much smaller trees, with a greater abundance of hardwoods, than occurred historically. This has important implications for salmonid habitat now and into the future, due to reduced shade (especially in larger lower-gradient channels) and the lack of a continual source of large wood inputs.

In the 1990s the California Department of Fish and Game (CDFG) conducted habitat typing surveys through the fish-bearing length of a number of Mattole tributaries. In many tributary streams these surveys recorded canopy cover well below the 80% target CDFG considers sufficient for providing temperature-moderating shade. These surveys did not specifically measure instream wood, but did assign pool shelter values, which are influenced by wood abundance. None of the tributaries surveyed in the Mattole met the "desirable" value of 100 (on a scale of 0-300) for pool shelter.

Figure IV-4.2: South Fork Bear Creek: Mature riparian vegetation in the King Range National Conservation Area. Note large Douglas-fir, understory, and log jam in background.

Tree growth and establishment (especially of alder species) since these surveys were conducted (and more broadly in the last ~30 years) has substantially increased canopy cover and improved riparian condition in many tributaries (see Figure 1). Surveys conducted in 2005 and 2007 found far fewer stream reaches lacking in canopy cover (Mattole Restoration Council, 2008). Most reaches lacking shade were either larger streams (~>35' bankfull width) that would only be shaded by mature conifers (if at all), reaches where past channel instability due to in-channel sediment and streamside landslides had prevented the establishment of woody vegetation, or reaches where near-stream conditions are currently inhospitable to the establishment of woody vegetation.

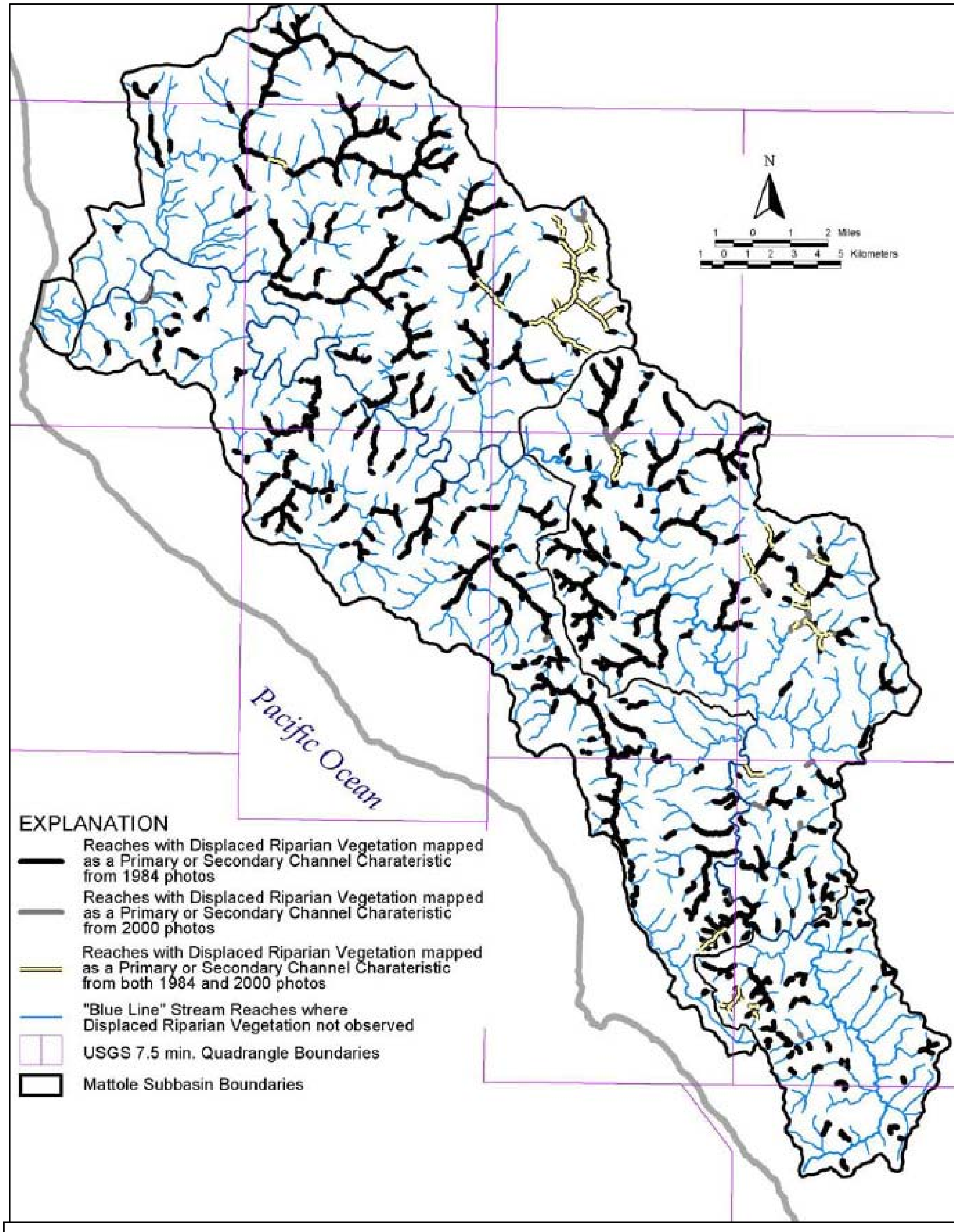

Figure IV-4.3: Based on aerial photo interpretation, between 1984 and 2000 the length of stream channel with "displaced riparian vegetation" decreased substantially in the Mattole. This general improvement in riparian condition is corroborated by residents' observations and other data. Source: Downie et al. 2003, page 109.

The North Coast Watershed Assesment Program report completed for the Mattole (Downie et al., 2003) notes a lack of pool habitat and cover, and poor potential for recruitment of wood to stream channels in much of the watershed. The report recommends adding large wood and cover structures to improve channel complexity (see also the Fisheries monograph). More recent surveys have also noted a general lack of instream large wood (MRC, 2008). Logging in the Mattole prior to the 1973 Forest Practices Act often involved cutting trees right up to streamside, and many streambeds were used as skid trails — often the easiest path in steep terrain. Widespread timber harvest outside the immediate riparian zone also reduced the potential for wood inputs from upslope sources through mass wasting and debris flows, when these events occurred. These were likely historically important wood input mechanisms in the steeper, more confined valleys in the watershed (Reeves, 2003).

In addition, prior to the late 1980s instream wood was intentionally cleared from many streams in the Mattole because of concerns about log jams inhibiting fish passage. These practices combined to leave few pieces of instream wood of sufficient size or length to exert an effect on channel complexity, and a lack of potential for recruitment of wood of any size. An additional consequence of reduced levels of wood instream is the increased chance that wood inputs to streams will be transported downstream and out of the system, due to the lack of "key" pieces or log jams that might otherwise retain debris.

Based on aerial photo analysis, Downie et al. (2003) noted a strong spatial correlation between streamside landslides and reaches with "negative mapped channel characteristics," such as displaced riparian vegetation and wide channels. The report concluded that these landslides were a primary cause of channel impairment within bedrock terrains (which is most of the tributary streams in the Mattole — contrasted to stream reaches within quaternary alluvial deposits). Certainly, some of these landslides are natural and inevitable, but their occurrence has been increased by a mix of factors, including channel aggradation and incision, and loss of near-stream vegetation.

C. Riparian Ecosystem Restoration

Since 2002, riparian reforestation has used a strategy of high-volume, site-specific and opportunistic conifer and hardwood planting in the riparian zone. In just seven seasons, more than 150,000 native Douglas-fir were planted along fifty-plus miles in twenty-one tributary creeks and the mainstem Mattole River. In addition, over 3,500 native redwoods were planted along eight streams, and over 10,000 native hardwoods were planted along nearly five miles of three streams.

In early 2008 we took stock of our riparian restoration strategies and concluded that we needed to broaden our tool kit to address a range of problems in the riparian zone. Based on site-specific evaluation of the successional stage and bank stability of each reach, we prescribe the planting of conifers, hardwoods, grasses, and brush as well as bioengineering and silviculture practices — tailored to enhance riparian recovery at each site. This Riparian Ecosystem Restoration Program consists of four major program components (these components are described in detail in “Management Strategies,” below).

-Successional revegetation using planting and seeding with native stock
-Conifer enhancement through hardwood and conifer thinning and stand conversion
-Instream wood addition using post-thinning materials
-Bank and landslide stabilization using revegetation and bioengineering

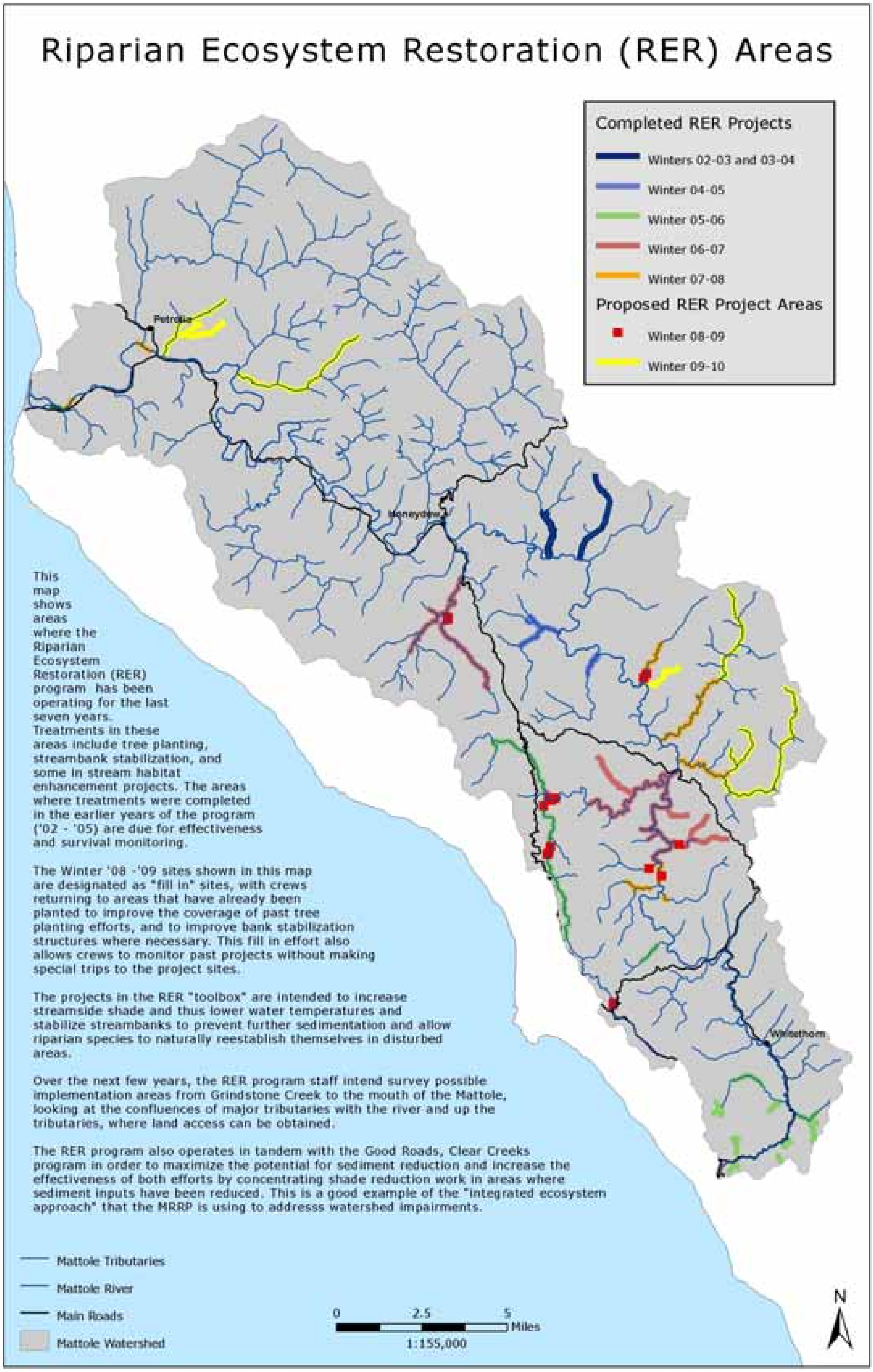
Riparian Ecosystem Restoration (RER) Areas
Completed RER Projects
Winters 02-03 and 03-04
Winter 04-05
Winter 05-06
Winter 06-07
Winter 07-08
Proposed RER Project Areas
Winter 08-09
Winter 09-10
Petrolia
Honeydew
Whitethorn
This map shows areas where the Riparian Ecosystem Restoration (RER) program has been operating for the last seven years. Treatments in these areas include tree planting, streambank stabilization, and some in stream habitat enhancement projects. The areas where treatments were completed in the earlier years of the program ('02 - '05) are due for effectiveness and survival monitoring.
The Winter '08 -'09 sites shown in this map are designated as "fill in" sites, with crews returning to areas that have already been planted to improve the coverage of past tree planting efforts, and to improve bank stabilization structures where necessary. This fill in effort also allows crews to monitor past projects without making special trips to the project sites.
The projects in the RER "toolbox" are intended to increase streamside shade and thus lower water temperatures and stabilize streambanks to prevent further sedimentation and allow riparian species to naturally reestablish themselves in disturbed areas.
Over the next few years, the RER program staff intend survey possible implementation areas from Grindstone Creek to the mouth of the Mattole, looking at the confluences of major tributaries with the river and up the tributaries, where land access can be obtained.
The RER program also operates in tandem with the Good Roads, Clear Creeks program in order to maximize the potential for sediment reduction and increase the effectiveness of both efforts by concentrating shade reduction work in areas where sediment inputs have been reduced. This is a good example of the "integrated ecosystem approach" that the MRRP is using to addresss watershed impairments.
Mattole Tributaries
Mattole River
Main Roads
Mattole Watershed
0
2.5
5
Miles
1:155,000
N

Figure V-4.4

2. Issues of concern

A. Insufficient Riparian Canopy

As noted above, through natural and human-assisted recovery, riparian vegetation has increased considerably in much of the watershed since the lack of canopy cover was first noted. While in some stream reaches lacking canopy cover the establishment of riparian vegetation may not be feasible due to channel migration or natural soil conditions, there are streams where restoration can speed the development of functional riparian canopy. Elevated water temperatures are of particular concern in stream reaches which might otherwise be suitable for coho or Chinook rearing habitat.

B. Unsuitable conditions for natural re-establishment of riparian vegetation

In some heavily impaired streams, floodplain conditions are unsuitable for natural regeneration of riparian trees (**see Figure V-4.1**, Mattole Canyon Creek)**.** Some stream systems contain a number of bars and terraces above the active channel, composed of coarse substrates, with little or no woody vegetation. These bars are a relic of the historic ’55 and ’64 floods, riparian clearing, and high sediment loads. Restoration can be used to speed up the establishment of woody vegetation and the development of a mature riparian zone.

C. Landslides and bank erosion

Historical land-use practices in the Mattole have increased the rate of streamside slides and bank erosion, which are a significant source of sediment in some stream reaches. Revegetation and bioengineering techniques can be used to reduce sediment delivery from some slides and eroding banks. However, slides and bank erosion do occur naturally, and can be important creators of habitat complexity, and sources of instream wood and nutrients.

D. Reduced abundance of instream wood

Instream wood plays a significant role in creating high-quality instream habitat for salmonids. Many streams in the Mattole currently contain very little instream wood, leading to reduced stream channel complexity, and reduced quality of winter and summer rearing habitat, especially important for juvenile coho salmon. The lack of mature streamside forests and interruption of natural wood input processes will continue to contribute to this wood deficit for many years without human intervention.

E. A long-term gap in instream wood recruitment

Riparian forests in the Mattole are currently composed of a high percentage of overstocked, young tanoak and Douglas-fir stands. Tree size and species composition of most riparian forests is poor for recruitment of instream large wood, leading to a long-term gap in wood recruitment until forests mature. Silvicultural practices can be used to decrease the time until these trees will be large enough to play a role in creating instream habitat, and increase conifer composition in some stands. Manual additions of wood to streams in the near-term will help create channel complexity in lieu of natural wood recruitment (also see Section V-3, Fisheries).

F. Where should the work be done?

The riparian reforestation section of the previous Mattole Watershed Plan (MRC 2005) included a rating matrix with factors such as salmonid presence and current habitat quality for prioritizing tributary streams for riparian restoration. Surveying and implementation work has been completed on many of those creeks since the plan was published, and future riparian assessments will be focused from Grindstone Creek (just downstream from Ettersburg) to the mouth of the Mattole. Riparian surveys have generally been done following sediment reduction activities. However, since adding riparian thinning and successional plantings to our toolbox, it may be worthwhile to revisit some creeks where Douglas-fir were previously planted.

i. Determining Priority Tributaries

In determining priority tributaries to work in, these factors have been considered:

1. Historic salmonid presence (especially coho)
2. Current salmonid presence (especially coho)
3. Intrinsic potential for coho habitat (from “intrinsic potential” maps created by the National Marine Fisheries Service, Figure V-3.5)
4. Collaboration with Good Roads, Clear Creeks (GRCC) program
5. Lack of shade, lack of large wood or wood recruitment potential, and unstable streambanks

ii. Prioritizing Implementation Sites

In prioritizing and applying riparian conifer enhancement treatments, the following factors are further considered at the reach and site scale:

- Ease of access to site (no more than a 45-minute walk from vehicle)
- Consultation with Mattole fisheries experts
- Treatment will not cause bank or hillslope instability (no more than a 45-degree slope)
- Site has overstocked Douglas-fir stands (thinning)
- Douglas-fir present but suppressed by hardwoods (conifer release)
- Site that was known to be dominated by Douglas-fir (air photo or stumps present) and is now dominated by hardwoods (stand conversion)
- Treatment will not cause adverse effects on stream temperatures by removing canopy cover

A final consideration is the relationship between the average DBH of the riparian stand and the bankfull width of the stream reach. The equation Dpf=2.5(Wbf), where Dpf is the diameter (cm) of a pool-forming log, and Wbf is the bankfull channel width (m) has been used to define the minimum diameter necessary for a log to exert a meaningful influence on channel morphology (Beechie and Sibley, 1997, Reentmaster, 2004). In stands where trees are already large enough to form pools, riparian thinning could actually reduce the potential for large wood recruitment by reducing the number of trees in the stand, and the incidence of density dependent mortality (Beechie et al., 2000).

3. Priority Issues, Goals and Management Strategies

A. Priority Issues and Goals

Riparian ecosystem restoration addresses three of the priority issues highlighted at the beginning of this plan:

Priority Issue 1) Sedimentation and temperature increases, as well as potential increases in nutrients, pesticides, and fuel run-off from expanding home sites and new residential development, will continue to impact the water quality and recognized beneficial uses of the Mattole River.

Priority Issue 3) Existing salmonid populations are threatened by decreased habitat quality and severely diminished overall numbers, weakening their ability to respond to negative changes in habitat quality and ecological processes.

Priority Issue 5) Current forest composition in the watershed is dominated by tightly stocked second-growth Douglas-fir and mixed hardwood forest that lack resiliency to significant ecological disturbances, such as stand-replacing wildfire, SOD, or pests, and provide little commercial incentive for sustainable timber management.

Goals

Goal 1) High-quality water of sufficient quantity throughout the watershed to support healthy populations of salmonids and the expected human population of the watershed.

Goal 2) Improved instream habitat conditions for salmonids throughout the basin and a reduction in the impact of limiting factors on salmonid populations.

Goal 3) Promote functioning natural processes supporting watershed resiliency and health.

A. Management Strategies and Milestones

The following strategies are intended to reach the following goals:

- Increase canopy cover to reduce water temperatures
- Increase potential for recruitment of instream wood of sufficient size to perform key ecological functions in the short and long term
- Reduce sediment inputs to streams from eroding banks and streamside landslides

Strategy 1: Successional Revegetation: In this treatment, we plant and seed native species chosen to aid the return of riparian vegetation. Depending on site conditions, this could include early-successional native perennial grasses and brush species, as well as the native conifers and hardwood riparian planting. These early-successional species establish well on recently disturbed sites that now need soil- and slope-stabilizing plants, and which also help prepare for return planting of tree species or natural succession.

Milestone 1-A: Establish riparian vegetation in areas lacking sufficient riparian cover in East Mill Creek, McGinnis Creek, Mattole Canyon Creek, Blue Slide Creek, Fire Creek and the lower 5 miles of the Mattole River by 2012.

Milestone 1-B: Continue to implement revegetation projects in coordination with GRCC sediment reduction projects as the program expands into the lower watershed (see Sediment Milestones for time frame)

Milestone 1-C: Identify riparian areas in tributaries and the mainstem Mattole river, downstream of Grindstone Creek where the establishment of riparian vegetation is limited by inhospitable site conditions, but permitted by fluvial processes by 2015.

Milestone 1-D: Create and implement site specific re-vegetation plans on identified sites in tributaries and the mainstem Mattole River, downstream of Grindstone Creek by 2020.

Milestone 1-E: Conduct the following monitoring actvities at 1 and 2 year intervals following project implementation:

- Pre- and post-project photos from established photo points
- Seedling survival plots capturing at least 3% of total seedlings planted
- Measures of vegetative cover and species abundance for control and treatment (seeded) plots

Milestone 1-F: Use monitoring results to help answer the following questions:

- Are seedlings surviving at an acceptable rate?
- What are the primary causes of seedling mortality?
- How effective are different seeding treatments at establishing vegetative cover?
- How does plant composition and establishment differ in seeded areas compared to controls?

Strategy 2: Riparian Conifer Enhancement (RCE): Historical logging in the Mattole removed large Douglas-fir in the riparian zone. In many of these areas riparian forests are currently dominated by tanoak and overstocked fir stands. Accelerating the development of late-successional forest characteristics and frequency of fir in these stands will increase the potential for recruitment of large instream wood. Fir is also important for stream shade in reaches where channels are too wide to be shaded by shorter hardwoods.

Restoration work in this category employs three silvicultural techniques:

- Conifer thinning in over-stocked second-growth conifer stands
- Small-scale second-growth tanoak-stand conversion
- Release of understory conifers from hardwood-dominated stands, by cutting or girdling hardwoods that are shading shorter conifers

Milestone 2-A: Treat 16 acres of riparian forest in South Fork Bear Creek, Bear Creek, East Fork Honeydew Creek, Grindstone Creek and other identified tributaries by 2012.

Milestone 2-B: Identify additional project areas, based on potential for high quality habitat coho rearing habitat, a current lack of instream large wood, and riparian stand conditions by 2015.

Milestone 2-C: Create and implement site-specific project plans in identified project areas by 2020.

Milestone 2-D: Conduct the following monitoring activities at 1 and 5 year intervals following project implementation:

- Pre- and post-project photos from established photo points
- DBH and stand density of trees in treatment and control plots comprising at least 2% of the project area
- Detailed notes will be kept on treatments and treatment costs in order to evaluate the cost-effectiveness of treatments relative to increases in tree growth
- Canopy cover will be measured using a solar pathfinder or densiometer in control and treatment plots (minimum distance between measurements 66’, 100’ commonly used).

Milestone 2-E: Use monitoring results to help answer the following questions:

- Has treatment resulted in increased tree growth rates relative to control stands?
- How cost-effective are different treatments relative to increased growth and increased large wood recruitment potential?
- Has treatment adiversely affected the percentage of canopy cover for stream shade?

Strategy 3: Instream wood addition using post-thinning materials: As a complement to the riparian conifer enhancement work, we use thinned-out riparian-zone trees to improve fish habitat. While this instream wood will not last as long as “large-wood”, it will enhance instream habitat now, aiding in the survival of salmonid populations. These wood inputs will eventually be replaced by a next wave of natural or human-abetted in-situ recruitment of instream wood.

Milestone 3-A: Place post-thinning materials at pools lacking sufficient cover in South Fork Bear Creek, Bear Creek, Lower East Fork Honeydew Creek, Grindstone Creek, and other identified tributaries by 2012.

Milestone 3-B: Identify pools lacking cover in RCE project areas by 2015.

Milestone 3-C: Create and implement site-specific wood placing projects in RCE project areas by 2020.

Milestone 3-D: Conduct the following monitoring activities at 0.5, 1, and 2 year intervals following project implementation:

- Pre- and post-project photos from established photo points
- All placed wood will be tagged in order to monitor movement after high flows
- Data is collected in order to measure changes in stream characteristics

Milestone 3-5: Use monitoring results to help answer the following questions:

- How long do structures remain in place?
- If displaced, where do structures end up?
- Has placed instream wood created scour, cover, or bank erosion?

Strategy 4: Bank and landslide stabilization using bioengineering: Through our work in riparian zones across the watershed we have found that a significant source of sediment comes from unstable banks and hillslopes immediately above streams. We use appropriate hand tools to construct willow walls, wing deflectors, and related bioengineering structures. In conjunction with the Good Road, Clear Creeks program, we identify and assess riparian-zone landslide sites that deliver sediment and prescribe appropriate revegetation and erosion control treatments (see sediment section,).

Milestone 4-A: Treat slides and eroding banks in Fire Creek and Little Grindstone Creek by 2012.

Milestone4-B: Identify treatable bank and landslide sediment sources in tributaries and the mainstem Mattole River, downstream of Grindstone Creek by 2015

Milestone 4-C: Create and implement site-specific stabilization projects on identified sites in tributaries, and the mainstem Mattole river, downstream of Grindstone Creek by 2020.

Milestone 4-D: Conduct the following monitoring activities at 0.5, 1, and 2 year intervals following project implementation:

- Pre- and post-project photos from established photo points
- Photos are examined in order to measure stabilization and vegetation changes in riparian, upslope and stream conditions adjancent to structures and overall success of project

Milestone 4-E: Use monitoring results to help answer the following questions:

- Have the treatments increased vegetative cover on the bank?
- Have the treatments reduced bank retreat?
- Have treatments reduced bank instability?

Strategy 5: Increase understanding of project effectiveness through project monitoring and maintenance: All RER projects employ pre- and post-treatment photos from repeatable photo points to document changes in site conditions. Additionally, data are collected on relevant parameters at appropriate intervals for each treatment.

Milestone 5-A: **Long-term monitoring of project effectiveness**
Results from some of these treatments may only be apparent at time intervals exceeding those of most funding contracts. Therefore, we will conduct long-term monitoring and site visits at 5- and 10-year intervals at 10% of sites. (although if long term funding can be secured, we would like to increase this percentage) This information will increase our understanding of how these treatments perform at longer time scales under a variety of environmental conditions.

Milestone 5-B: Site Maintenance

Re-vegetation, Bioengineering, and Conifer Enhancement sites will be monitored for maintenance the first summer following implementation, and will be checked visually to determine maintenance needs, if any exist. Upon inspection of the treatment areas, if there appears to be signs of water stress, damage from browsing, competing vegetation or damage to the bank stabilization structures due to high flows, a variety of maintenance treatments can be employed including browse protection, irrigation, removal of competing vegetation, weed-mat and mulch installation, and repair to riparian fencing.

Strategy 6: Increase understanding of past and present condition of Mattole riparian forests.

Milestone 6-A: Increased understanding of the current state of Mattole riparian forests

A more thorough understanding of the current state of Mattole riparian forests will help target our restoration efforts and provide a baseline against which to compare recovery. Some data currently exist which can be used in this analysis, including canopy and large wood surveys, and CalVeg data which include tree size and vegetation classes. However, in many cases these are incomplete data-sets. Identifying current data gaps and analyzing existing data will help identify areas of deficient riparian canopy, and potential areas for silvicultural treatments.

Milestone 6-B: Increased understanding of wood recruitment potential and pathways of wood recruitment

An increased understanding of the spatial and temporal potential of riparian forests in the watershed to contribute wood of sufficient size to streams could help target riparian thinning treatments and the placement of instream wood (see fisheries section) to stream reaches with the longest lag time before tree growth allowed natural recruitment to provide instream wood. An enhanced understanding of the relative contribution of instream wood through different input processes would also aid in ensuring that those processes are free to occur, and there is wood to be recruited. This could be a particular concern in the more densely settled areas of the watershed, where streamside roads and homes may limit the potential for recruitment through bank erosion and natural channel migration. These areas may require continual artificial wood inputs in order to maintain instream habitat.

“Wood budgets” which attempt to quantify the abundance, input and transport rates and processes of wood in a watershed are one approach to answering some of these questions (Benda and Sias, 2003). Air-photos, GIS analysis, and forest growth and decay models have also been used to predict wood recruitment potential to stream channels (Beechie et al., 2000, Hyatt et al., 2004)

Milestone 6-C: Increased understanding of the historical status of riparian forests and instream wood along the mainstem Mattole River, and their potential contribution to salmonid habitat

Currently, there is little mature riparian forest along the mainstem Mattole, especially in the lower river. The extent of historical riparian forest is uncertain — flat river-bottom land was undoubtedly some of the first (and easiest) to be cleared by Euro-American settlers in the watershed. Recent research from the Pacific Northwest has shown that in some large rivers draining temperate forests, the role of large wood in creating in-channel habitat has been greatly underappreciated (Abbe and Montgomery, 2003, Montgomery et al., 2003). Identifying areas along the mainstem where riparian forests could be enhanced or maintained as a long-term source of instream wood could help provide enhanced habitat for juvenile salmonids.

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Sediment

Number 4 in the
2009 State of the Mattole Watershed Series

Companion to the Mattole Integrated Coastal
Watershed Management Plan

Mattole River and Range Partnership

Mattole Restoration Council
Mattole Salmon Group
Sanctuary Forest

August 31, 2009

Table of Contents

Sediment Management

1. Current Conditions in the Mattole

Historic and current land uses have exacerbated already-high sedimentation rates in the Mattole River watershed (Downie et al. 2003). The result is degraded salmon and steelhead habitat in most of the basin. Historic accounts, including early photos (from 1875-1940) and aerial photographs from 1942, portray the Mattole River system with a much different morphology. Pools were deeper. There was far less erosion of mainstem river terraces.

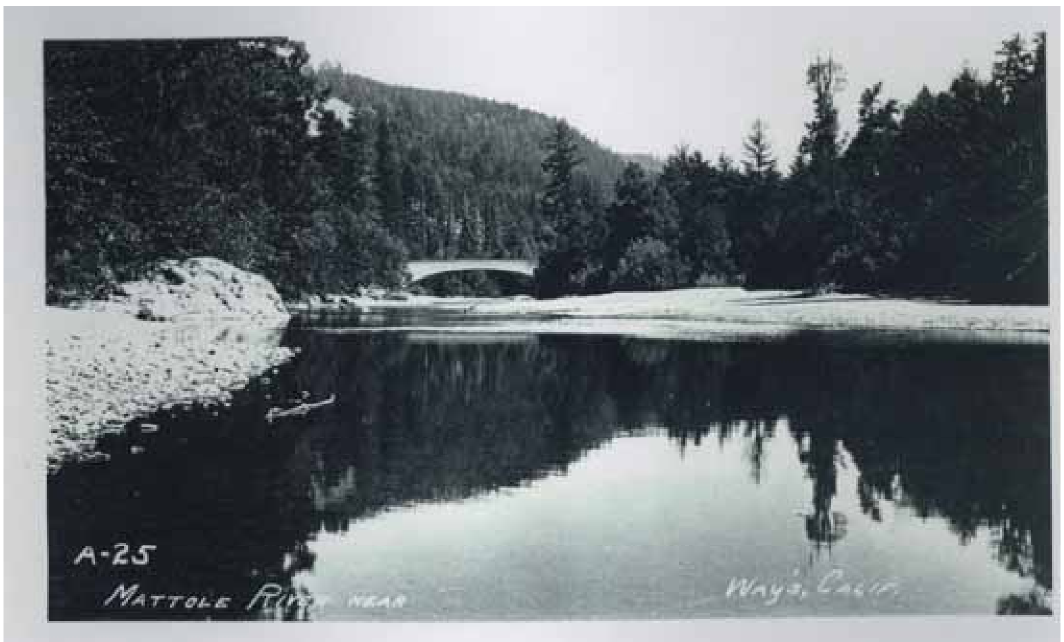

Figure 1: Upstream from A.W.Way County Park, 1930s
SOURCE: Photo courtesy of the Mattole Valley Historical Society.

More areas of mature riparian vegetation included large conifers, narrower channels, and smaller gravel bars upstream of the estuary (Downie et al. 2003). See Figure 1.

These historic conditions facilitated thermal stratification, habitat cover, and streamside shading that moderated summertime water temperatures. The river system provided suitable habitat for robust runs of salmonid species (fall-run Chinook salmon, coho salmon and winter-run steelhead), as well as a substantial population of summer-run steelhead, now-extinct green sturgeon (CDFG 1972), and a spring Chinook run (Moyle et al. 1995). In the wake of extensive timber harvest and road construction, very large floods in 1955 and 1964 generated significant basin-wide mass wasting and road-related sedimentation, fundamentally altering channel morphology in many tributaries (NCRWQCB 2002). Sediment loads, at their current, high level, have pervasive effects on the geomorphology and aquatic habitats in the river system:

- When sediment inputs vastly exceed flushing rates, river systems store sediment in lower-gradient channels and in floodplains (Leopold 1994). This results in channel aggradation, causing the river to become shallower and wider, and accelerating rates of lateral channel movement (Rosgen 1996).

- Excessive aggradation and accelerated sediment loads make re-establishment of riparian vegetation difficult on floodplains. Aggradation results in large gravel bars that cannot support vegetation in the winter due to scour from flood flows and during summer drought when the bars are often above the wetted stream channel. In the lower mainstem and larger tributaries, increased rates of sediment transport resulted in accelerated channel migration (Leopold et al. 1964), impacting the extent and age structure of gallery cottonwood/conifer forests.

- Bank erosion accelerates as wider sediment-laden channels increase erosion rates along banks and activate dormant landslides above the channels.

Taken together, these changes damaged Mattole salmon and steelhead habitat by raising summertime water temperatures, reducing aquatic habitat complexity, and burying stream channels. In this chapter, we propose an approach to upslope sediment control that seeks to reduce sediment inputs into the river system, allowing it to return to historic conditions that facilitate salmon abundance.

A. Natural and Human Caused Sediment Production in the Mattole

The Mattole watershed is a tectonically active area with some of the highest rates of crustal deformation, surface uplift, and seismic activity in North America (Merritts and Vincent 1989; Merritts 1996). Even without recent human impacts, the natural rate of erosion in the Mattole is among the highest in the continental United States (NCRWQCB 2002). There is ample evidence from the widespread presence of old landslide scars that an unusually large amount of sediment production in the watershed is due to natural mass wasting events.

Landslides are common on steep, rapidly uplifting terrain composed of highly erosive sedimentary bedrock (O'Louglin and Pearce 1982), especially in conditions of intense rainfall. These landslides likely resulted from strong seismic shaking that destabilized slopes which gave way during high rainfall events and hillslope saturation.

The other process driving sediment production was natural and anthropogenic fire. Most of the Mattole basin exhibits fire-adapted vegetation, with the landscape showing evidence of varied fire return intervals. Some of these fires likely had severe

impacts on vegetation cover with greatly increased surface erosion and mass wasting during high rainfall in the years immediately after the fires (Debano et al. 1998).
Table 1 depicts sediment yields from natural process and land-use activity based on aerial photo interpretation and limited field checking[1]. This analysis was based on review of a subset of aerial photographs from different Mattole subbasins dating back to 1941. The estimates are uncertain but the numbers are consistent with sediment source analysis in a range of 40-50% (Kramer et al 2001). Table 1 presents rough estimates of current erosion rates of 8,000 tons/mile^2/year. Of this, an estimated 2,900 tons/mile^2/year (36%) are accounted for by a variety of natural sources.

The following are estimates for sediment yield per square mile in other California areas[2] (NCRWQCB 2002): Van Duzen River: 2,232 tons/mile^2/year, Redwood Creek: 4,750 tons/mile^2/year, San Gabriel Mountains: 5,173 tons/mile^2/year.

Table 1: Natural and Management-Related Sediment Yields in the Mattole by NCWAP Subbasin (North Coast Regional Water Quality Control Board 2002). The table indicates annual tons per square mile, and thus the entire watershed figures are an average of the sub-basins

Sediment Source Estimated Sediment Delivery (tons/mi2/yr)	North	East	South	West	Entire Watershed
Natural Mass Wasting	3,700	1,600	1,600	2,100	2,400
Stream Bank Erosion	790	270	170	360	460
Natural Erosion Total	4,500	1,900	1,800	2,500	2,900
Road-Related Mass Wasting	2,000	5,900	450	2,100	2,900
Road-Stream Crossing Failures	50	40	160	40	50
Road-Related Gullying	100	190	290	200	170
Road-Related Surface Erosion	360	670	780	560	540
Skid-Trail Related Erosion	590	700	760	850	710
Other Harvest Related Delivery	600	140	150	1500	700
Road Erosion Total	2,500	6,800	1,700	2,900	3,700
Harvest Activity Erosion Total	1,200	840	910	2,400	1,400
Erosion Total for All Sources	8,200	9,500	4,400	7,800	8,000

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These estimates offer only a snapshot of large-scale geologic processes. Without a deeper understanding of the range of variability and rates of natural processes such as

[1]Because of their complexity, we will not review the methodologies used to arrive at these figures. The methods did undergo peer review, and were accepted by the USEPA.
[2] In contrast to this sedimentation rate, the small forested basin where one author did research in NE Oregon had a sediment loss rate measured at about 2.5 tons/square mile a year, while intensively cultivated wheat lands has gross erosion rates of about 1,000 tons/mile^2/year averaged over last 35 years. Even in unmanaged Northern California streams, fine sediment loads appears to be much higher than other streams in the Pacific NW (California Regional Water Quality Control Board 2002), largely due to the unusually erosive sedimentary geology in the region.

large landslides, we cannot claim a complete understanding of the ratio of natural versus management-related sediment sources in the basin. Some geologists still insist that natural sediment production rates in the Mattole are even higher than the figures presented here, but these data indicate that current management-related sediment sources exceed natural sediment sources by a factor of almost 2 to 1.

B. The Mattole in the Geologic Time Frame

This astonishingly high erosion rate of 8,000 tons/square mile/year in the Mattole is less than the natural erosion rates over the last two million years. During this time, the Mattole has uplifted very rapidly by geologic standards (NCRWQCB 2002). Over the last 45,000 years there has been an estimated two mm uplift/year averaged over the entire watershed[3]. This amounts to an incredible 0.2 meters per century of uplift, although this almost certainly came in brief periods and represents an overall average over time. In the April 1992 earthquake sequence, it was estimated that some areas along the coast west of the Mattole rose as much as 1.4 meters while some areas inland subsided 0.4 meters.

The sedimentary material that forms the mountains of the Mattole watershed is estimated to have eroded at roughly the same rate as uplift. This equates to 12,800 tons/mile^2/year average sediment yield[4]. If these figures are approximately correct, over the past 45,000 years the Mattole has removed from the basin a quantity of sediment equal in volume to the 296 square mile area of the watershed and 300 feet deep. The elevated floodplain terraces 20 meters high flanking the mainstem Mattole below Honeydew are evidence of remnants of very large sediment deposits in the distant past – sediments that have been flushed through the system. These terraces also show how the river has cut down through material that has been uplifted (Merrits and Vincent 1989).

Given these high historical sediment yields, how do we interpret the more recent human impacts that have almost extirpated the Mattole salmon runs? The only clear answer we can offer is that since 1950 these sedimentation events have been distributed across the entire watershed. In contrast to the widespread disturbance between 1945-70, under natural conditions the watershed was unlikely to have been so uniformly disturbed that that salmonid habitat was destroyed basin-wide.

In the distant past, such natural events were more localized (Reeves et al. 1995), and even if extirpated in some areas, there were refugia for salmonids that allowed the fish to persist within the larger watershed (Montgomery 2004). Individual tributaries likely ceased to provide habitat at smaller temporal and spatial scales, but the

[3]Area outside Mattole to east of Garberville on more stable terrain was estimated to uplift at about 1 mm/year so estimated eastern Mattole at about 2mm/year and western Mattole at 2-4 mm/year.
[4]This high figure indicates overall slope denudation rates not necessarily direct delivery to channels. Much eroded slope material may accumulate on lower slopes for eventual delivery to stream channels but given the steep slopes, this is relatively rapid in the Mattole.

watershed as a whole could maintain viable salmonid populations with less disturbed tributaries serving as refugia for salmonids (Sedell et al. 1997).

2. Issues of Concern

Most observers agree that natural recovery from the logging-era erosion is a long-term prospect[5]. It is certain that recovery will proceed at different rates throughout the watershed based on differences in geologic stability, land-use impacts, and sub-basin configuration. There are few reliable quantified data on current volumes of sediment delivery per year from various areas of the Mattole watershed, and no data on the volume of sediment transported out to the ocean relative to peak flows. Existing limited data are largely based on aerial photo interpretation within the post-timber harvest timeframe.

There have been estimates in Redwood Creek, a similarly configured basin in northern Humboldt County, for how long it takes large bedload "slugs" of sediment to move downstream through the mainstem. These "slugs" are estimated to move at 700 to 1700 meters/year. If rates of movement are similar in the mainstem of the Mattole, bedload would move through the entire 62-mile-long Mattole in 26 to 65 years. If the 1964 flood was the largest driver of sediment production in the Mattole since Euro-American settlement, we might assume that a significant part of the sediment generated in that storm has already moved through much of the system.

This may not be apparent in the lower mainstem, but the movement of sediment seems to be visible in smaller tributaries where recovering riparian vegetation appears to suggest stabilization of floodplains. Field visits and aerial photo reviews suggest that many of the upper Mattole tributaries are recovering from land-use impacts and the major floods of 1955 and 1964 that delivered sediment from disturbed hillslopes into the stream channels. Redwood Creek studies have shown that small, high-gradient tributaries flush material out at a higher rate than lower gradient streams.

Down-cutting, or excavation of stored sediments at various points within the upper mainstem, has also been observed. Along the Mattole headwaters, there are locations where the river has cut through all sediments down to bedrock, indicating that sediments deposited in the logging era have already moved through this part of the system. This is not necessarily a positive contribution to salmonid habitat since many areas of the watershed lack large wood in-channel. Had more large wood been present, sediments in the headwaters might have moved out slower, leaving high-quality aquatic habitats.

MRC's Riparian Ecosystem Restoration program, described in more depth in Number 7 of the State of the Mattole Series and Foresight 2020, offers different restoration strategies to address the lack of riparian vegetation in many reaches of the Mattole. The integration of the sediment management and riparian ecosystem

[5] Additional large-scale sediment inputs, similar to the Honeydew Slide, a Spring 1983 mass wasting event, might reverse current positive trends in aquatic conditions.

strategies will provide a multi-faceted approach to reducing sediment loads and increasing the recruitment potential for large wood in targeted reaches.

Mattole River Watershed Assessment Report (Downie et al. 2003, Figures 31, 32, and 33) maps indicate a clear spatial distribution in the recovery of streamside vegetation and channels. Based on aerial photo analysis, features indicating excess sediment production, transport, and storage decreased between 1984 and 2000 by 42% by length. The extent of this recovery varied greatly between hard, moderate, and soft bedrock types (see Figures 17, 18, 19, and 20 for maps showing different bedrock types and occurrence of landslides). There was little or no recovery in large floodplain and alluvial areas such as the lower Mattole as these areas are still accumulating and storing sediment from upstream sources.

3. Management Objectives

Since 2002, MRC's Good Roads, Clear Creeks program has upgraded and removed roads in a number of sub-basins in the middle and upper reaches of the Mattole (Figure 3). The NCWAP report (Downie, et al, 2003) identified sediment and temperature as the most important limiting factors for salmonids, and the Mattole was listed as impaired by the EPA and placed on the 303(d) list for both sediment and temperature. In order to address the sources of sediment, the MRC developed the GRCC program, which has been very successful at improving roads and stabilizing a number of landslides.

In a 1993 inventory of the Mattole, the NWRQCB estimated that there were 3,350 miles of active and abandoned roads in the Mattole. Of these 115 miles were maintained by the County and 25 miles were maintained by the BLM. This leaves 425 miles of active and 2,800 miles of abandoned roads that are not actively managed or maintained. While this estimate does not account for private landowner management on the 425 miles of active road, it still illustrates the magnitude of the amount of potential sediment that the abandoned roads represent.

The strategies of the GRCC program have been developed with input from the Mattole Technical Advisory Committee and built on techniques developed by restorationists dealing with the legacy of logging throughout the Pacific Northwest (and discussed in depth below).

The sediment reduction strategies of the GRCC program address a number of the Priority Issues that will be guiding the work of the MRRP over the next 10 years. Sedimentation is one of the root causes of many of the habitat and water quality issues in the Mattole. The GRCC program will help to lessen the amount of sediment entering the system by stabilizing the leading edge of stream side slides, reducing stream bank erosion, and improving or removing roads throughout the watershed. These techniques, in conjunction with the Riparian Ecosystem Restoration Program, and the Mattole Salmon Group's habitat enhancement work found in the Fisheries section, will begin to reduce the impact of sediment on habitat and water quality in the Mattole.

Throughout the 1980s and 1990s, techniques were developed to control sediment through the decommissioning and stormproofing of roads (Weaver and Hagans 1996). To achieve benefits in the most cost-effective manner, these techniques employed the same types of heavy equipment that created the roads. Basic techniques range from drainage improvements to complete obliteration and re-contouring of roadbeds. For more in-depth information on this topic, Appendix A, "Road and Streambank Sediment Treatment Techniques."


Figure 2: Mill Creek culvert. MRC Photo

More recently, restorationists have resumed treating streambank erosion. While intervening in these dynamic locations is challenging, the benefits are clear: sediment stabilized at unstable streambanks decreases direct sediment inputs into watercourses. Streambank stabilization sites are prioritized by cost effectiveness alongside road-related sites. Streambank stabilization utilizes bioengineering methods that often integrate other salmon habitat enhancement features such as habitat cover, riparian planting, and large wood placement.

This strategy seeks to treat streambank sites where bioengineered structures can stabilize the toes of active shallow landslides as a means of preventing these landslides from delivering large volumes of sediment to fish-bearing watercourses. This strategy reduces inputs of sediment into watercourses while improving sensitive aquatic habitats. In conjunction with upslope road treatments, it addresses the source of the sediment problem rather than treating symptoms or end results of sedimentation further downstream.

In order to be effective, sediment reduction projects also must incorporate a community outreach component. Since the Mattole watershed is 80% privately owned, the participation of private landowners in sediment reduction activities is essential. Sediment reduction efforts must educate landowners on the causes of sediment and the reduction strategy while offering information to reduce sediment on their own through restoration activities and changes in land management.

A. Sediment Reduction Principles in the Mattole Watershed

MRC's sediment reduction strategy directs stabilization of sediment sources on hillslopes and streambanks though cooperative projects with private landowners and public land managers at tributary watershed scales. The following principles guide the design and completion of these projects:

i. Project Prioritization

Sediment reduction projects are prioritized by the location of high-quality salmonid habitat. These habitats will be prioritized by refugia characteristics such as low summertime water temperatures, V-star values, presence of protected lands, and riparian canopy cover. Iterative assessments of un-treated tributaries will determine future project areas (i.e. once the highest-quality tributary watersheds have been treated, the effort will move to the second-highest quality set of tributary watersheds). A new watershed-wide sediment modeling project will help us understand in a more detailed way how sediment moves through the watershed to further guide sediment reduction projects.

ii. Sediment Reduction in a Sub-basin Context

Sediment reduction work will occur within selected groupings of tributary watersheds. Concentrating work sequentially into discrete project areas (typically 4,000-12,000 acres) generates sufficient landowner interest to achieve a density of treatments that impact sediment production in a given area. Grouping work sites by project area reduces treatment costs but project areas are not so large as to be infeasible to implement. MRC has set a goal of treating sediment sources on at least 70% of the land area within any project area.

iii. Cost Effectiveness

By applying a cost-effectiveness standard, work is limited to those sites where action can be reasonably taken, and ensures that funding can be used effectively. Cost-effectiveness guidelines are linked to habitat quality: stabilizing a cubic yard of sediment in a relatively pristine tributary is more likely to have beneficial results than stabilizing sediment in very degraded tributaries where limited work may not improve fisheries habitat.

iv. Voluntary Participation

All landowner participation in sediment reduction activities is voluntary. Landowners have the options to participate, complete the work on their own, or take no action. Landowners have input on the design of treatment options to be used on their lands as long as cost-effective sediment reduction goals are met.

v. Monitoring

All work will be monitored to demonstrate contract performance, trends in watershed recovery, and effectiveness of restoration treatments.

vi. Minimize Short-Term Impact

Because sediment reduction work involves ground disturbance, measures are taken to minimize short-term impacts to sensitive habitats. Measures include tree planting, seeding, mulching, post-equipment hand-work and installation of grade-control structures if appropriate.

4. Management Strategies

The following project sequence is intended to guide the process of identifying and prioritizing project sites. Sediment reduction work targeted at accessible locations in order to stabilize and reduce sediment at road and streambank treatment sites. Methods are based on prescriptions developed in a site-specific sediment source inventory. A sediment reduction project consists of four components: outreach, inventory, treatment, and monitoring. The sequence of a project is described more fully in Appendix C of the Mattole Watershed Plan (2005): "Good Roads, Clear Creeks (GRCC) Project Sequence."

i. Inventory

Once landowner permission has been secured, inventories on cooperative lands will identify sediment sources. Prescriptions for treatment options will follow. Inventories will use either the Jack Monschke Watershed Management "Star Worksheet Methodology," the Pacific Watershed Associates Road Inventory protocol, or the Dept. of Fish and Game's *California Salmonid Stream Restoration Manual Road Inventory Protocols* (Monschke 2000, PWA 2001, CDFG 2004). In each of these protocols, an aerial photo review identifies potential sediment sources for further field investigation. At these sites, data on sediment source type, potential delivery volume, delivery likelihood, and potential treatment feasibility are collected. Calculations based on field data will determine treatment prescription, cost-effectiveness, and treatment priority.

All sites that have the potential to deliver greater than ten cubic yards of sediment to a fish-bearing watercourse are identified. Prescriptions are developed for sites meeting cost-effectiveness guidelines. All inventory data is geo-referenced and entered into the Mattole Geographic Information System (GIS), maintained by MRC. Landowners receive inventory results and treatment prescriptions in a customized landowner packet.

ii. Road Treatments

Road-related sediment sources receive treatment to reduce the risk of catastrophic failure and to minimize chronic sediment production. Treatments generally seek to reduce concentration of runoff and improve the stability of runoff locations such as rolling dips, culvert outfalls and ditch-relief culverts. Treatments include installing features such as adequately sized and properly positioned culverts, rolling dips, critical dips, and bridges. They also include road reshaping components such as outsloping and crowning. Road segments that are removed are "hydrologically decommissioned," meaning re-contouring to allow for full runoff across the road prism, but not necessarily full replacement of fill materials into the original hillslope configuration.

iii. Streambank Treatments

Streambank treatments are limited to sites where aggraded channels are exacerbating sediment delivery at active landslides. Stabilizing the landslide toe reduces upslope sediment delivery risk. Willow and rock structures bioengineer streambanks while also maintaining aquatic habitat value. These structures are typically 20-200 feet in length, and are constructed within the summertime wetted channel.

iv. Treatment Costs

Cost for treatment varies with a number of factors:

- **Size of treatment site:** Some stream crossing excavations may move only a few dozen yards of road fill, while one in the King Range contained 60,000 cubic yards. Similarly, streambank treatment sites can vary in length along the bank. Site size and configuration determine the amount of heavy equipment time it will take to complete the treatment.
- **Access:** Many sites are accessible to heavy equipment, with minimal pre-project brushing and clearing. Other sites, particularly abandoned roads, often require extensive clearing before or during the project. Access to some sites requires road reconstruction. Some sites are so inaccessible that no treatments are prescribed because gaining access could cause extensive sedimentation.
- **Remoteness:** Sites requiring lengthy travel for personnel and heavy equipment cost more to treat than sites near major roadways.
- **Materials:** Culverts, fuel, rock, downspout structures, and bridges add cost.

Projects receive public (and some private) funding from a variety of sources. These funds are intended to improve salmonid habitat, improve water quality and aquatic habitats, and restore watershed conditions.

A. Current Status of Existing Sediment Reduction Projects

As of the publication of the first Mattole Watershed Plan (2005), several sediment reduction projects are complete, others are at various stages of the implementation process, and others are still in the inventory phase. Project status is summarized in Table 2. Project areas are delineated and sites are located on Figure 3, following the table.

Table 2: Past and Planned Projects of the Good Roads, Clear Creeks Program

Project	Acres	Inventory Status	Inventory Cost	Implementation Status	Implementation Cost (est.)	Sediment Stabilized (yards^3)
Lower Mill Creek	1,337	Completed 2000	$24,000	Completed 2002	$103,000	16,500
Middle Mattole/ Panther Gap	16,790	Completed 2002	$101,000	Initiated 2004, Completed 2005	$603,000	78,200
Whitethorn and Bridge to Mill (aka Upriver)	13,013	Completed 2003, 2004	$65,500	Initiated 2005, Completed 2007	$1,200,000	62,870
Eubanks	11,696	Completed 2004	$50,000	Initiated 2006, Completed 2008	$1,000,000	57,970
Bear Creek	18,212	Completed 2005	$45,000	Initiated 2007, Exp. completion 2009	$800,000	53,850
Blue Slide, Mattole Canyon Creek	20,043	Completed 2006	$60,000	Initiated 2007, Exp. completion 2010	$1,900,000	226,040
Mcginnis to Mouth (Petrolia)	24,555	Completed 2007	$50,000	Initiated 2008, Exp. completion 2010	$1,400,000	93,240
Honeydew Creek	14,592	Project proposed	N/A	N/A	N/A	N/A
Upper North Fork to Dry	22,904	Inventory on select ranchlands	N/A	N/A	N/A	N/A
Squaw Creek	22,877	Inventory on select ranchlands	N/A	N/A	N/A	N/A
Lower North Fork	23,113	Inventory on select ranchlands	N/A	N/A	N/A	N/A

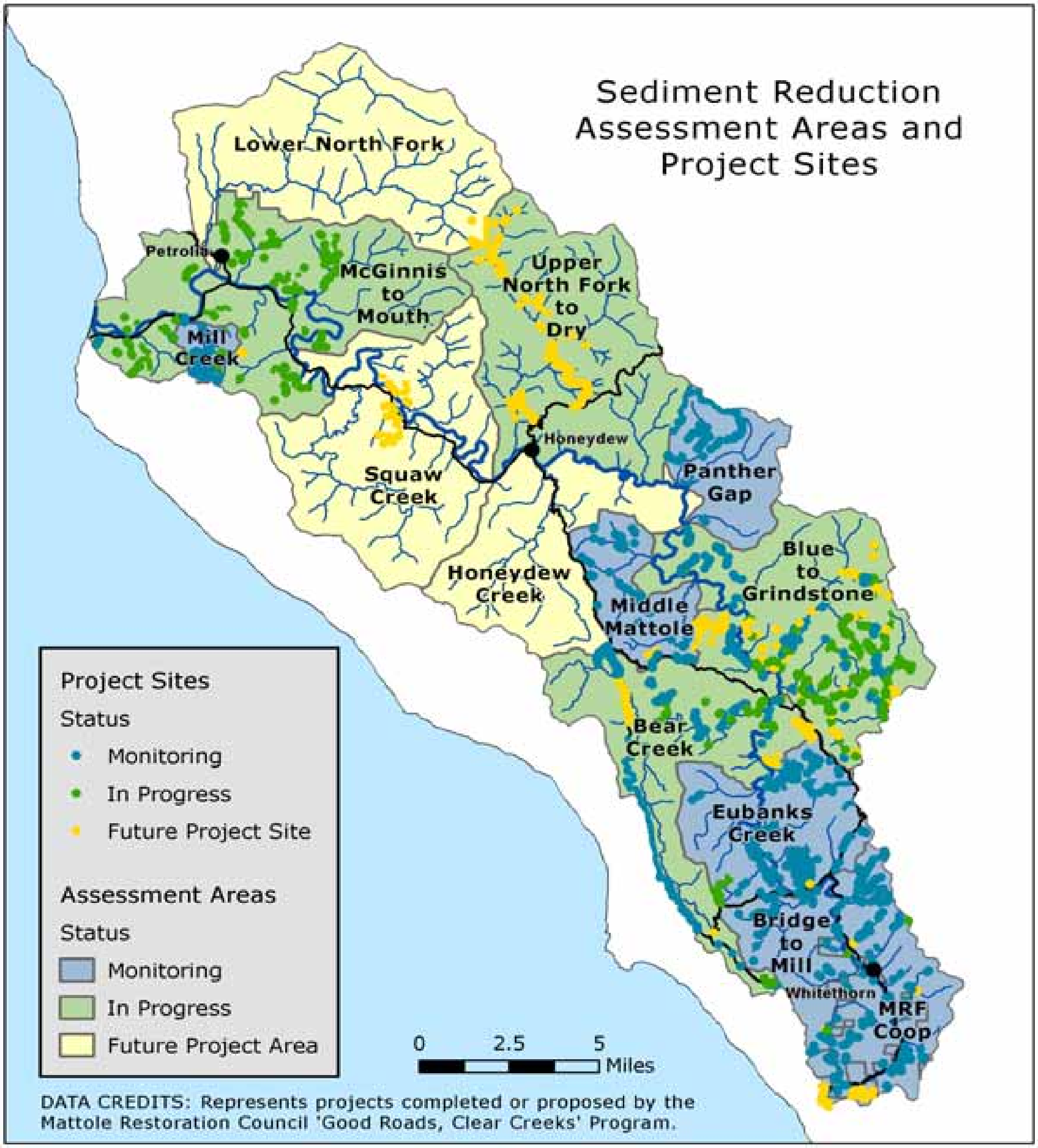

Figure 3: Good Roads, Clear Creeks Project Sites and Areas -- The areas where the program has focused since its inception. While many sites have been inventoried and prescriptions have been developed, the middle reaches of the watershed have yet to be surveyed.

Project Name: Telegraph and Paradise Ridge Good Roads, Clear Creeks Project (Eubanks)

Beginning in 2006 GRCC projects have been improving drainages and roads within the Big Finley, Little Finley, Buck, Deerlick, Eubanks, and Nooning Creek tributaries to the Mattole River. After the project reaches completion in the summer of 2008, approximately 57,970 cubic yards of sediment will have been prevented from entering the Mattole River watershed over the three years of implementation work. Several miles of road have been reshaped by crowning and outsloping road segments. Nearly fifty culverts have been installed, all designed to withstand a 100-year flood events. In addition, some of the most exciting and large scale GRCC projects were performed replacing old culverts that were impeding fish access and installing bottomless pipe arches. These structures allow salmon and steelhead trout to freely migrate under the road expanding their spawning and rearing habitat.

Project Name: Bear Creek Project

The GRCC program is working to reduce sediment in the Bear, French and Wolf Creek sub-watersheds to the Mattole River. Over the course of the project, 53,850 cubic yards of sediment will be prevented from entering the watercourses. Numerous culverts and drivable rock-armored fords will be installed on seasonal roads and miles of road will be reshaped to reduce surface erosion. Local operators complete all of the heavy equipment work.

Project Name: Blueslide, Mattole Canyon and Grindstone Creek Project

The GRCC program plans to stabilize 226,040 cubic yards of sediment over the course of the project within this project area. This region of the Mattole watershed has unstable geology and is prone to large landslides. Numerous instream sites are planned to stabilize the toe of these slides with bioengineered rock structures. These structures will reduce erosion on the unstable stream bank, keeping the water flowing in the center of the valley and allowing for regeneration of the riparian vegetation that naturally stabilizes the streambank. Several miles of road will also be storm-proofed within this project area.

Project Name: Mcginnis to Mouth (Petrolia Area) Project

In 2007, GRCC personnel performed a sediment source assessment on the roads and streams within the lower Mattole watershed. This project area encompasses the McGinnis, Conklin, East Mill, Jeffrey Gulch, Jim Goff Gulch, Collins Gulch, Lower Bear, Stansberry, Mill, Clear, Indian, and Wild Turkey Creek tributary watersheds.

The GRCC staff identified over 100 sites with the potential to reduce 72,540 cubic yards of sediment from entering the watercourses. As of late 2008, funding to treat these sites is approximately 95% secured and the implementation phase will begin in the summer of 2008 and reach completion in 2010.

Project Name: Ranchlands Water Quality Program

Due to the fact that the majority of land that has yet to be inventoried between Honeydew and Petrolia is in ranchland ownership, the MRC has developed this program with the goal of outreach and relationship building with this important set of stakeholders. So far sediment assessments have been performed on four ranches within the Squaw, Upper, and Lower North Fork Project areas. GRCC staff is actively pursuing further ranchland involvement for development of implementation projects on these properties.

B. Future Project Overview

The GRCC program has already identified a number of projects that will bring the program's successful model developed over the last few years to untreated areas in the watershed. The following projects will be implemented as funding and landowner participation allows over the timeframe of this Plan. These projects have been identified as part of the GRCC program, prior to the Watershed Plan process. Therefore this chapter contains basin specific projects, unlike many of the other sections in this plan. Strategies and techniques for sediment reduction going into the future are expected to be very similar to those employed by the GRCC between 2002-2008. Methods for identifying project sites, willing landowners, and applying prescriptions will remain the same. Section F, Future Sediment Management Strategies, outlines the newest addition to the GRCC toolbox, a sediment model. This model, which as of the writing of this Plan is in the initial phases of development, aims to pinpoint regions where excessive sedimentation is adversely affecting hydrological and biological processes within the watershed. In addition, it will help to quantify the degree of erosion, thereby distinguishing tributary watersheds where funds can be used efficiently from those that are so erosive that restoration efforts could be cost prohibitive at this time. Please refer to Section F for more details.

Project Name: Honeydew Creek Project

In 2009, the MRC is seeking funding to perform a sediment inventory on the area encompassing Honeydew Creek, Bundle Prairie and unnamed Mattole River tributary upstream of Honeydew Creek. This project area is approximately 13,840 acres, of which 7,750 is managed by BLM. Because sediment sources on BLM lands have been inventoried through the Honeydew Creek Watershed Analysis, only the 6,090 acres of private lands will be inventoried. Honeydew Creek supports all three Mattole salmonid species.

Most of the Honeydew Creek drainage is on federal land, and sediment sources have largely been treated within these lands. Remaining lands in the sub-basin have a high road density. The first large-scale sediment control project in the Mattole was the decommissioning of the last 3.5 miles of the King Range Road. This work was designed to benefit Honeydew Creek's salmonid habitat. Honeydew Creek is considered a "Tier 1 Key Watershed" in the federal Northwest Forest Plan, and BLM has invested several million dollars in sediment control on federal lands. This project would complement that investment by undertaking treatments on cooperative private lands.

Project Name: Upper North Fork to Dry Creek Project

The project area consists of Dry Creek, two unnamed Mattole River tributaries, and the Upper North Fork. Project access is through Mattole Road (Bull Creek Road), Doreen Drive, Windy Nip Road, Fox Camp Road, and numerous private roads. The project area is approximately 22,900 acres. Of this, Humboldt Redwood Company owns 8,740 acres, which is likely to be inventoried. Estimated inventory area is 12,000 acres (projected 50% participation by acreage).

Dry Creek and the Upper North Fork of the Mattole River generate high volumes of sediment amidst an unstable landscape. Much of the Upper North Fork is owned by the Humboldt Redwoods Company, who has indicated interest in allowing access for sediment source investigations. Remaining lands are largely owned by interested landowners. Dry Creek is one of the most aggraded creeks in the Mattole basin, yet contains habitat for steelhead trout, and likely historically contained habitat for coho and Chinook salmon.

Project Name: Squaw Creek Project

This project includes numerous small tributary sub-basins (Woods, Kendall, Hadley, Saunders, Cook, Granny, Holman, Singley, Pritchett, Thornton, and two unnamed Mattole tributaries) as well as Squaw Creek, a major Mattole tributary. Access to the project area is through Mattole Road, Smith-Etter Road, and numerous private roads. The project area is approximately 22,900 acres, including 4,150 acres of BLM ownership. It is anticipated that 60% of this project area is accessible for survey, so the estimated inventory area is 13,700 acres. This project area contains Squaw Creek, a large tributary which supports all three Mattole salmonid species. In addition, Saunders Creek hosts a small steelhead run and Woods Creek provides habitat for steelhead and coho salmon. Several of these creeks are also identified as cold water contributors to the mainstem Mattole, which has elevated summertime water temperatures throughout this region. The upper portions of the Squaw Creek basin are managed by BLM.

Project Name: Lower North Fork Project

This project encompasses lands within the Lower North Fork of the Mattole River. Access is through Mattole Road, Clark Road, North Fork Road, Bear River Road, and numerous private roads. The project area is 22,700 acres. Of this, approximately 50% is likely accessible for inventory, so the inventory area is 11,400 acres. The Lower North Fork is the Mattole's largest tributary, hosting runs of steelhead trout, and likely Chinook and coho salmon. The downstream reaches of the Lower North Fork are highly aggraded, sometimes resulting in flooding around the Petrolia area. Riparian vegetation in this large channel is impacted by high rates of lateral movement. Upstream, ongoing timber harvest and road construction aggravate unstable slope conditions and soft geology. While timber access roads have been upgraded recently in some upper basin areas, significant sediment source reduction work remains.

D. Measuring the Effectiveness of Sediment Reduction

Monitoring the environmental and biological response to sediment reduction is difficult at all scales. Sediment transport is episodic, making evaluation a long-term and technically challenging proposition which the MRC plans to address by 2014. Sediment transport from hillslopes to bedload and in-channel transport happens during extreme weather and earthquake events, which are difficult to analyze statistically over short monitoring periods.

The following monitoring questions will guide sediment reduction effectiveness monitoring in the Mattole River watershed:

- Are aquatic habitats responding to watershed restoration and natural recovery? What is the relative contribution of each?
- What is the geographic distribution of recovery within the basin?
- Are treatments performing as designed in a one-, five- and ten-year year time period?
- Are sediment-related water quality and physical stream channel metrics (e.g. V-star, substrate embeddedness, pebble counts, and residual pool depths) showing improvement in treated areas? In untreated areas?

Three types of monitoring are conducted to assess sediment reduction efforts:

On-Site Monitoring

This includes photo documentation and georeferencing in all cases, and may include the collection of turbidity grab samples to measure chronic turbidity from short-term treatment impacts, cavity measurements to determine any post-project erosion from stream crossing excavations, and other specific monitoring measures designed to assess the performance of work at a site level.

Channel Monitoring

Channel monitoring includes the collection of up to eight channel health and biological metrics: V-star, substrate embeddedness, riparian canopy density, pebble counts, water and air temperatures, longitudinal profiles, thalweg profiles and cross sections. These measurements are taken in a monumented study reach of 20-30 bankfull widths, at either a fixed or randomly selected location (depending on study design).

E. Outreach and Education for Sediment Reduction

In the Mattole, sediment reduction efforts contain a significant outreach and education component. This integrated effort is critical in attracting private landowners to participate in projects and in increasing awareness of sediment-friendly land-use options.

- **Landowner Liaisons:** In a given project area, one or more Landowner Liaisons are identified and retained. Liaisons are generally residents or landowners within the project area, and are the primary point of contact for landowner interface with MRC personnel. They recruit landowner participation, coordinate field visits, and facilitate access to private lands.
- **Landowner & Contractor Training:** Occasional training in sediment reduction inventory and treatment techniques is a means of educating landowners and residents who wish to work independently or with MRC on sediment reduction projects. Training lasts two to five days, and is held every 2-3 years. Landowners and heavy equipment operators who have taken the course often integrate concepts into ongoing road maintenance activities.
- **Fact Sheets:** A series of fact sheets is developed and distributed, covering topics such as creek care, good road design, road surfacing, road maintenance, road removal, stable streambanks, culverts, Total Maximum Daily Load (TMDL), log jams, landslides, geomorphic terrains, and trends in sediment recovery. These fact sheets are available online at www.mattole.org, at the MRC's Community Resource Center, or at local businesses.
- **Complimentary Road Inspections:** Personnel are available to inspect private road systems and will provide recommendations for repair or upgrade options.

Publications and resources for landowners wishing to undertake sediment reduction and fish-friendly land management should refer to Appendix C in the Sediment Chapter of the 2005 Mattole Watershed Plan, "Land-Use Recommendations for Sediment Control."

F. Future Sediment Management Strategies

To efficiently move forward with sediment reduction, more information was needed regarding the intricacies of spatial and volumetric variations of sediment delivery and transport throughout the Mattole Watershed. In June 2008, the MRC began the initial phases of developing the *Mattole Watershed Sediment Modeling Project,* aiming to develop a watershed-wide sediment model that would aid the GRCC program in understanding how sediment is being delivered and moving through the system. This project aims to pinpoint regions where excessive sedimentation is adversely affecting hydrological and biological processes within the watershed. In addition, it will help to quantify the degree of erosion, thereby distinguishing sub-watersheds where funds can be used efficiently from those that are so erosive that restoration efforts could be cost prohibitive at this time.

The proposed sediment modeling project will have two phases. Currently, funding is being sought for the first phase, which will serve as a small test-run before expanding the model to the entire watershed. Phase One will focus on outreach and research, as well as sediment modeling in a small tributary watershed. Completion of this smaller-scale project first will provide a better understand of the model's limitations and fine-tune the process before undertaking the larger, watershed-wide project. In addition to fundraising, other preliminary work is already underway, building support for the project through outreach and communication with experts in related fields and researching similar modeling projects.

Interest in the project has already been expressed by agency representatives from the State Water Resources Control Board, the National Oceanic and Atmospheric Administration, as well as local restorationists. Spearheading the project for the MRC will be GRCC Program Director Joel Monschke who has a number of years of experience working in the geological and hydrological landscape of the Mattole watershed and a relevant educational background (BS in Engineering Geology and Hydrogeology and an MS in Geotechnical Engineering).

As it stands in the preliminary phase, sediment input data will come from the following sources:

1. SWRCB TMDL values will be used for baseline data and, where possible, will be modified by higher resolution subwatershed data generated through extensive office and field review.
2. MRC sediment assessment data will be used to incorporate load reductions resulting from treatment of sites and potential delivery from untreated sites.
3. Landslide inventories evaluated in conjunction with Shalstab stability modeling will be used to estimate sediment loads from different Shalstab slope classes; this information will then be used to identify and quantify background erosion throughout the watershed.
4. Small-scale sediment delivery data will be incorporated

5. If funding is available, LIDAR will be employed to gather high resolution topographic data used to further detail landforms such as roads and slides.

Sediment Transport Modeling will include the following steps:

1. A hydrologic model (possibly the EPA's Hydrological Simulation Program-FORTRAN (HSPF)) based on digital elevation and other GIS data will be used as the transport and modeling mechanism for sediment.
2. Sediment transport formulas considering both bedload and suspended sediment will be integrated into the hydrologic model.
3. The model will be calibrated based on specific channel conditions and ongoing monitoring throughout the watershed.

It is expected that this project will take at least two years to reach completion and even after that point there will be continued adjustment as the model is calibrated to match field data collected from stream reaches. This model will help validate past sediment reduction work, guide project development, and predict future scenarios. The final outcome will be a sediment model integrated with MRC's GIS software that will identify current sediment loading of all stream reaches within the Mattole watershed. This baseline information will then be combined with information detailing current and historic salmonid population distribution to locate high-priority areas for additional restoration activities. Using the model, the GRCC program will be able to prioritize every sub-basin throughout the entire Mattole watershed and make educated decisions regarding the location and scope of sediment reduction projects.

The model will also identify areas most sensitive to development or timber harvest activities. The MRC intends to share the model with associated organizations dealing with forestry, low flow, and fisheries issues to expand the collective impact of the MRRP in restoring this landscape to a healthy and functioning ecosystem for all its inhabitants. In addition, the model could act as a state-of-the-art template to help other watersheds that experience biological degradation caused by excessive sedimentation.

Management Strategies

Strategy 1: Complete the road improvement and other sediment reduction programs of the Good Roads, Clear Creeks program: Continue to implement and monitor the sediment reduction projects outlined in Section B that are planned or underway in each of the delineated subbasins, and institute an appropriate maintenance agreement with landowners to ensure the longevity and continued effectiveness of the projects.

Strategy 2: Model the natural and human induced sediment production throughout the Mattole: Develop the Mattole Sediment Model (MSM) for test use and calibration with input from professionals and agency

Strategy 3: Continue to develop and test the model against to ensure accuracy: Refine the MSM with further input and field checks of modeled reaches and sub basins.

Strategy 4: Incorporate new methods and techniques to reduce sedimentation and move towards TMDL compliance. Continue to research and develop new sediment control and prevention techniques such as bedload excavation through collaborative development with the TAC and other restoration practitioners to address sedimentation at a scale commensurate with TMDL requirements.

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NORTH COAST INTEGRATED REGIONAL WATER MANAGEMENT PLAN

North Coast Integrated Regional Water Management Plan
Proposition 84 Round 1 Implementation Grant

Priority Project Technical Documents: Plans and Specifications

358 - Mendocino Headwaters Integrated Water Quality Enhancement Project, Mendocino County RCD

- Galbreath Preserve Road Inventory, 2007
- Hare Creek and Little North Fork Big River, PWA Report #08081401, 2008
- Lawson Ranch Road Inventory, NRCS' Yokayo Rancheria Trip Report, 2004
- Upper Rancheria Preliminary Biogeomorphic Assessment, 2006

Erosion sites, as defined in this assessment, include locations where there is direct evidence that future erosion or mass wasting will deliver sediment to a stream channel. Sites of past erosion were not inventoried unless we determined that there was potential for additional future sediment delivery. Similarly, sites of future erosion that were not expected to deliver sediment to a stream channel were identified but were not included in the assessment.

To complete the field inventory, all roads were walked and inspected by trained personnel, and all existing and potential erosion sites were identified. Inventoried sites for this assessment primarily consist of stream crossings, potential and existing landslides related to the road system, gullies below ditch relief culverts, and long sections of uncontrolled road-surface and ditch runoff that currently discharge to the stream system. For each identified existing or potential erosion source, we completed a database form (Appendix A) and plotted the site location on a field base map (Figure 2). Information on each field data form includes: (1) site location, (2) nature and magnitude of existing and potential erosion problems, (3) the likelihood of erosion or slope failure, (4) length of hydrologically connected road surface, and (5) recommended treatments to eliminate erosion at the site or minimize its risk as a future source of sediment delivery.

PWA personnel estimated the erosion potential (and potential for sediment delivery) for each problem site or potential problem site, and the approximate volume of sediment expected to be eroded and delivered to streams. These estimates provide quantitative assessments of how much sediment could be eroded and delivered in the future if no erosion-control or erosion-prevention work is performed. In a number of locations, especially at stream diversion sites, the actual sediment loss could easily exceed our field estimates. All sites were assigned a treatment priority, based on their potential or likelihood to deliver sediment to stream channels in the watershed, and based on the cost-effectiveness of the proposed treatment. Also, during the assessment stream crossing sites were evaluated for potential fish barrier problems.

Fieldwork also included collecting survey data at most stream crossings using standard tape and clinometer techniques. These data were used to develop longitudinal profiles and cross sections for the stream crossings, and calculate sediment volume using the STREAM computer program. The survey data for these locations allow for quantitative, accurate, and reproducible estimates of: (1) future erosion volumes, which reflects the consequences of a possible storm-generated washout at the stream crossing; or (2) upgrading volumes, which estimates excavation requirements to complete a variety of road-upgrading and erosion-prevention treatments (i.e., culvert installation, culvert replacement, complete excavation, etc.).

Where new or replacement stream crossing culverts were being recommended for installation, the culverts were sized using two different methods to predict the 24 hour, 100-year recurrence interval discharge. The culvert sizing calculations occurred at all stream crossings where the field estimated channel dimensions were greater than three foot by one foot in cross sectional area.[1]

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[1] In catchments with small drainage area, as reflected by steep, mountain stream channels with small, 3 ft^2 cross sectional areas, hydrologists, geologists and engineers have no accurate methods for sizing culverts. Consequently, PWA treatment prescriptions default to a minimum size of a 24" culvert at these smaller stream channels with 3 ft^2 or smaller cross sectional areas. This size will not only accommodate the 24 hour, 100-year recurrence interval discharge, but also lowers the risk of the culvert inlet plugging with debris and sediment.

The two methods were: (1) **either** the Rational Method (Dunne and Leopold, 1978), an analytical approach based on rainfall intensity and watershed characteristics for drainage areas less than 80 acres, **or** for drainage areas larger than 80 acres, the empirical equations of the USGS Magnitude and Frequency Method (Wannanan and Crippen 1977), and (2) the Hasty Method, a field determination of predicted peak flow based on estimating flood flow channel dimensions.

For the final phase of the GWP project, data analysis occurred when all the inventory information had been collected, properly entered in the database, and checked for completeness. The use of a relational database allows for rapid data analysis. Data searches were performed to isolate the nature, frequency and magnitude of a host of problems and treatments. Specific searches included analyses of the frequency and volume of potential sediment delivery associated with each sediment source (landsliding, fluvial erosion and surface erosion), the frequency of undersized culverts, stream crossings with a diversion potential, etc. Data tables developed for the Phase 3 summary report contain information regarding: (1) the number of sites recommended for treatment, (2) erosion potential, (3) treatment immediacy (priority), (4) sediment savings, (5) recommended treatments, (6) excavation volumes, (7) estimated heavy equipment and labor hours, and (8) costs.

5 SEDIMENT SOURCES

Sources of erosion in the GWP area are divided into two categories: (1) sediment from specific treatment sites, and (2) sediment from the surfaces of road segments of varying lengths—and their associated cutbanks that are hydrologically connected to the treatment sites (Figure 2; Table 1).

5.1 Types of Treatment Sites

5.1.1 Stream crossings

A *stream crossing* is a ford or structure on a road (such as a raised road prism or bridge) installed across a stream or watercourse (USDA Forest Service, 2000). In the GWP, stream crossings are the most common type of treatment site (Figure 2; Table 1). The rate of sediment delivery from stream crossings is always assumed to be 100%, because any sediment eroded is delivered directly to a stream channel. Furthermore, any sediment delivered to small ephemeral streams will eventually be transported to downstream fish-bearing stream channels.

Common problems that cause erosion at stream crossings include: (1) crossings without culverts, (2) crossings with undersized culverts, (3) crossings with culverts that are likely to plug frequently, (4) crossings with logs or debris buried in the fill intended to convey stream flow (i.e., *Humboldt crossings*), (5) crossings with a potential to be diverted, and (6) crossings that are currently diverted.

A *fill crossing* is an example of a stream crossing without a culvert to carry the flow through the road prism. At such sites, stream flow either crosses the road and flows over the fillslope, or is diverted down the road via the inboard ditch. Most fill crossings are located at small Class II or Class III streams that only have flow during larger runoff events.

Table 1. Frequency of sites with future episodic road-related erosion and sediment delivery, by problem type, and associated hydrologically connected road length, SSU Galbreath Wildlands Preserve, Mendocino County, California.

Site Type	Treatment sites		Hydrologically connected road reaches to treatment sites[1]		Total roads surveyed (mi)
	Inventoried (#)	Recommended for treatment (#)	Inventoried (mi)	Recommended for treatment (mi)	
Stream crossings	57	57	3.87	3.87	-
Landslides	2	2	0.03	0.03	-
Ditch relief culverts	20	18	3.23	3.17	
"Other" sites[2]	13	13	1.13	1.13	-
Total	**92**	**90**	**8.26**	**8.2**	**13.1**

[1]*Hydrologically connected road reaches adjacent to treatment sites* are lengths of road that are eroding and delivering sediment to those sites.
[2]*Other sites* include point-source springs, and hydrologically connected road segments not adjacent to treatment sites.

Large volumes of erosion may occur at stream crossings when culverts are too small for the drainage area and storm flows exceed culvert capacity, or when culverts become plugged by sediment and debris. In these instances, flood runoff will spill onto or across the road, eroding the stream-crossing fill. Alternately, the stream crossing may have a *diversion potential*, which means that flow is diverted down the road, either on the roadbed or in the ditch, instead of spilling over the fill and back into the same stream channel. In this case, the roadbed, hillslope, and/or stream channel that receives the diverted flow may become deeply gullied or destabilized. These hillslope gullies can become quite large and capable of delivering significantly greater quantities of sediment to stream channels (Hagans et al., 1986). Diverted stream flow discharged onto steep, unstable slopes can also trigger large hillslope landslides.

Stream crossing culverts must be able to convey a 100-year storm flow, as well as sediment in transport during high flows to be considered adequately sized (Pacific Watershed Associates, 1994). Undersized culverts do not have the capacity to convey stream flow during periods of heavy rainfall, and are more likely to become plugged by sediment and debris. Because the majority of roads in the GWP were constructed more than 20 years ago, many stream crossing culverts are substandard, i.e., are not large enough to convey a 100-year flow, or are installed at too low a gradient through the stream-crossing fill to prevent plugging. Improper culvert installations such as these were once common because they required shorter lengths of pipe to convey flow through the road, and were therefore used to cut costs. However, in the long run these

Noyo-Big River Watershed Management Plan Project

Part I: Hare Creek and Little North Fork Big River Watersheds (Jackson Demonstration State Forest)

Mendocino County, California

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1 PROJECT SUMMARY

At the request of the Mendocino County Resource Conservation District, Pacific Watershed Associates Inc. assessed 15.2 mi of forest roads in the watersheds of Big River and Hare Creek within the bounds of Jackson Demonstration State Forest. Using field inventories and data analysis, PWA identified a total of 166 individual sites and approximately 13.6 mi of roads with associated ditches and cutslopes that are either currently eroding and delivering sediment to streams in the EBLNFBR watershed, or show a strong potential to do so in the future. Of these totals, PWA recommends treating 162 sites and 13.5 mi of road for erosion control and erosion prevention. Recommended treatment sites include 75 stream crossings, 43 ditch relief culverts, 13 landslides, 13 sites of bank erosion, 10 springs, 2 swales, 3 gully diversions, and 3 discharge points for road surface erosion. Field analyses indicate that treating these individual sites and eroding road segments could prevent delivery of more than 31,765 yd^3 of sediment to streams in Jackson Demonstration State Forest during the next decade. The total estimated cost to implement all recommended treatments is $1,575,190. This total is based on current and projected material costs and California State prevailing wage rates.

The expected benefit of completing the erosion control and erosion prevention treatments recommended in this report lies in the reduction of long-term sediment delivery to Big River, and Hare Creek which are important streams for salmonid production in northern California. This assessment includes prioritized recommendations for cost-effective erosion prevention and erosion control, which, when implemented and employed in combination with protective land use practices, can be expected to significantly contribute to the long-term improvement of water quality and salmonid habitat in the area. With this detailed assessment, entities interested in the sustainability and preservation of salmonid habitat in the Hare Creek and Big River watersheds, and achievement of TMDL targets for reduction of anthropogenic related sediment discharge, can advance efforts to obtain funding to implement the recommended road related erosion remediation.

2 CERTIFICATION AND LIMITATIONS

This report, entitled *Noyo-Big River Watershed Management Plan Project, Part I: Hare Creek and Little North Fork Big River Watersheds, Jackson Demonstration State Forest, Mendocino County, California*, was prepared by or under the direction of a licensed professional geologist at Pacific Watershed Associates Inc. (PWA), and all information herein is based on data and information collected by PWA staff. Sediment-source inventory and analysis for the project, as well as erosion control treatment prescriptions, were similarly conducted by or under the responsible charge of a California licensed professional geologist at PWA.

The interpretations and conclusions presented in this report are based on a study of inherently limited scope. Observations are qualitative, or semiquantitative, and confined to surface expressions of limited extent and artificial exposures of subsurface materials. Interpretations of problematic geologic and geomorphic features (such as unstable hillslopes) and erosion processes are based on the information available at the time of the study and on the nature and distribution of existing features.

The conclusions and recommendations contained in this report are professional opinions derived in accordance with current standards of professional practice, and are valid as of the submittal date. No other warranty, expressed or implied, is made. PWA is not responsible for changes in the conditions of the property with the passage of time, whether due to natural processes or to the works of man, or changing conditions on adjacent areas. Further, information contained in the report should be reevaluated after a period of no more than three years, and it is the responsibility of the landowner to ensure that all recommendations in the report are reviewed and implemented according to the conditions existing at the time the work is undertaken. Finally, PWA is not responsible for changes in applicable or appropriate standards beyond our control, such as those arising from changes in legislation or the broadening of knowledge, which may invalidate any of our findings.

The site-specific and road related treatment prescriptions recorded on the project site sheets and compiled in the digital project database are standard treatments based on current sediment reduction techniques. Because standard treatment plans cannot describe all technical aspects of actual site-specific treatment locations, prescriptions, and technical specifications it is imperative that pre-implementation layout and on-the-ground implementation supervision be completed by or under the direction of a licensed geologist with professional experience in road and trail construction and erosion control techniques. This will be necessary to ensure the proper installation and effectiveness of the sediment control techniques prescribed in this assessment.

Certified by:

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3 INTRODUCTION

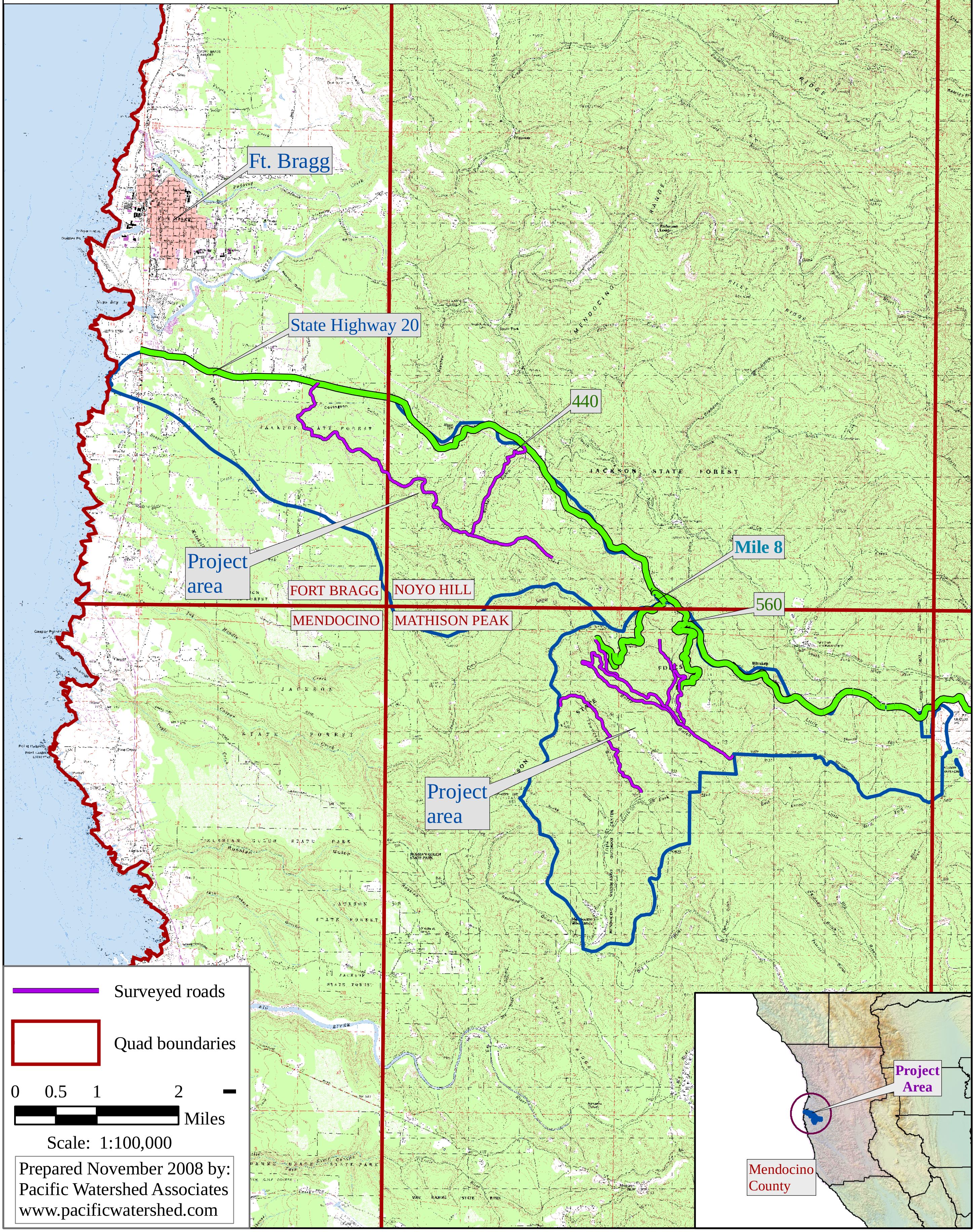
One of the most important elements of long-term restoration and maintenance of both water quality and fish habitat along California's west coast is the reduction of future impacts from upland erosion and sediment delivery. Sediment delivery to stream channels from roads and road networks has been extensively documented, and is recognized as a significant impediment to the health of salmonid habitat (Harr and Nichols, 1993; Flosi et al., 1998). Unlike many watershed improvement and restoration activities, erosion prevention through "storm-proofing" rural, ranch, and forest roads provides immediate benefits to the streams and aquatic habitat of a watershed (Weaver and Hagans, 1999; Weaver et al., 2006). It measurably diminishes the impact of road related erosion on the biological productivity of the watershed's streams, and allows future storm runoff to cleanse the streams of accumulated coarse and fine sediment, rather than allowing continued sediment delivery and in-stream deposition from managed areas.

Both Hare Creek (HC) and the Little North Fork Big River (LNFBR) are anadromous salmonid-bearing streams along the Mendocino coast. They contain habitat for steelhead trout and more importantly for coho salmon in their lower reaches (Flosi et al., 1998). Currently, road related erosion is a recognized threat to water quality and salmonid habitat in within the basin.

To address road related erosion problems in the HC and LNFBR watersheds, the Mendocino County Resource Conservation District (MCRCD) contracted Pacific Watershed Associates Inc. (PWA) to assess a network of roads on Jackson Demonstration State Forest (JDSF) property, a publicly owned working forest approximately 20 mi west of Willits, California (Map 1). PWA geologists completed an assessment of 15.2 mi of roads on the property during the summer of 2008. The goals of the project were to (1) identify and quantify all current and potential erosion problems associated with selected access roads and significant spur roads on the property; and (2) develop a prioritized plan for long-term erosion control and erosion prevention for these roads.

In this report we provide results of the field assessment and data analysis, and a prioritized list of recommendations for implementing erosion control and erosion prevention treatments to reduce road related erosion in the project area. All treatment prescriptions follow guidelines described in the *Handbook for Forest and Ranch Roads* (Weaver and Hagans, 1994), as well as *Parts IX* and *X* of the California Department of Fish and Game *Salmonid Habitat Stream Restoration Manual* (Taylor and Love, 2003; Weaver et al., 2006). Assessment data are summarized in Tables 1-5, Maps 2 and 3, and Appendix B. An overview of the terminology and techniques used in the assessment are provided in Appendix A. Projected requirements for heavy equipment and estimated project costs are provided in Tables 6 and 7, and typical drawings showing construction and installation techniques for the recommended erosion control and erosion prevention treatments are provided in Appendix C.

Map 1. Location of the Noyo-Big River Watershed Management Planning Project, Part I, Jackson State Forest ownership, Mendocino County, California.



4 FIELD DESCRIPTION OF THE ASSESSMENT AREA

4.1 Climate, Terrain, and Local Geology

The climate of north-coastal California in the HC and LNFBR watersheds is characterized by dry, mild-to-warm summers and cool winters with periods of intense rainfall and minor snow accumulation during cold storms. Mean annual precipitation is approximately 51 in., with most of the rainfall occurring between November and April. Elevation ranges from approximately 120 ft to 1000 ft within the assessment area (USGS, 1978, 1991a, 1991b).

The HC and LNFBR watersheds include moderately steep, mountainous terrain, with hillslope gradients frequently exceeding 70% along inner gorges located along main stem and tributary stream channels. Higher elevations along the northwestern section of the assessment area are composed of marine terraces characterized by relatively flat surfaces which are dissected and incised by local streams. Dense vegetation attests to abundant water and areas of fertile soil but the region is also home to the “pygmy forest,” a stunted forest landscape characterized by less fertile soils and shallow hard pans of marine terraces. Watershed forests consist primarily of redwood and Douglas fir, with lesser amounts of hardwoods such as tan oak and madrone.

The geology of the HC/LNFBR watersheds is primarily composed of sheared and potentially unstable rocks of the Coastal belt Franciscan Complex. Poorly consolidated sedimentary and sheared metamorphic rocks that are particularly susceptible to erosion and mass wasting during periods of sustained or heavy rainfall are exposed throughout the watershed. Alluvial deposits are found in the lowland settings of valley floors. Large-scale mass wasting is evident in the watershed, often characterized by rotational or translational debris sliding and earthflows (Braun et al., 2005). An example of this is a large, active, compound debris slide in the upper portions of Berry Gulch. This slide extends from an upper midslope position on the hillside to the creek below. The slide shows signs of recent activity characterized by pistol butted trees, hummocky topography, diverted watercourses, and surface cracking through the road prism. This slide encompasses Road 550 through the switchback section and is partially responsible for the midslope hydrologic disruption. Similar to many North Coast watersheds, other mass wasting features such as hillslope debris slides, slumps, cutbank slides and road fill failures are evident throughout the HC/LNFBR watersheds.

Several species of anadromous salmonids are present in the HC/LNFBR watersheds. Higher order channels are especially important for coho salmon. Of significance for salmonid habitat, the combination of high rainfall and erodible, potentially unstable geologic substrate, results in high rates of erosion and sediment delivery from road networks to stream channels. The lower tributaries within the basin alternately traverse gorges with steep and unstable slopes, and low-gradient areas characterized by sediment deposition and accumulation. Whereas salmonid populations have evolved and flourished with the natural processes of rainfall and erosion in the area, the impact of anthropogenically induced erosion (e.g., from resource management and road construction) has resulted in accelerated sediment delivery to streams and a degradation of salmonid habitat in this important watershed.

4.2 Roads Assessed in Jackson Demonstration State Forest

The HC and LNFBR watersheds each contain independent road networks to support land use transportation and resource management activities (Maps 1-3). The Hare Creek watershed road network is located south of, and accessed from, Highway 20. The western access road to this area is Road 400 which drops down to Hare Creek via Covington Gulch. Road 440 is the eastern access road, which follows Bunker Gulch down to Hare Creek. In the LNFBR watershed, inventoried roads are in the areas of Berry and Thompson Gulches, and are accessed from Highway 20 via Roads 560 and 500, respectively (Maps 1 and 2).

4.2.1 Hare Creek watershed roads (Roads 400 and 440)

PWA assessed Roads 400 and 440 (totaling approximately 6.5 mi) in the Hare Creek Watershed (Maps 2, 3). Roads in the watershed include maintained and unmaintained sections, and are used to access industrial timber production and recreational areas along the north side of Hare Creek. The roads support vehicular traffic except for the stream crossing at Walton Gulch, where the crossing is currently washed out[1], and the southeastern segment of Road 400, which is overgrown.

Road 400 and most of Road 440 are maintained mainline access roads surfaced with coarse aggregate base and surface rock. They have culverted drainage structures at most stream crossings, and are drained through the use of infrequent ditch relief culverts. One exception to this maintenance characterization is the upstream (easternmost) segment of Road 400, east of Bunker Gulch. This section of road is overgrown and unmaintained, but is still accessible by ATV or on foot. Of the 23 culverted stream crossings on Roads 400 and 440, 20 have drainage structures not sufficiently designed for the 100-year peak storm flow[2], and 29 of the 38 total stream crossings inventoried show a potential to become diverted because they lack critical dips necessary to prevent this. Along most road segments, excessive inboard ditches drain directly into stream crossings and hydrologically connected[3] ditch relief culverts, and as a result fine sediment from road runoff, ditch incision, and cutbank ravel is being delivered directly into the watershed's streams. In general, the most obvious sources of road related sediment within the Hare Creek watershed (under-designed stream crossings and chronic road surface runoff) are also widely observed in other industrial road systems in Mendocino County. The alignments for Road 440 and the first 0.5 mi of Road 400 are in narrow valleys directly adjacent to the stream channels, exacerbating bank erosion of the native hillside and the road fillslopes in these areas. PWA is recommending treatment for a number of sites along the alignments, but as there is no room to realign the roads within the stream valleys, and alternative road routes are not possible, we predict that episodic bank erosion will continue to be problematic in these areas.

[1]Jackson Demonstration State Forest currently has plans for upgrading this crossing.
[2]The *100-year peak storm flow* for a location is the discharge that has a 1% probability of occurring at that location during any given year.
[3]*Hydrologically connected* describes sites or road segments from which eroding sediment is delivered to stream channels (Furniss et al., 2000).

4.2.2 Little North Fork Big River watershed roads (Roads 550, 555, 561, and 730)

Inventoried roads in the LNFBR watershed include approximately 8.7 mi of maintained roads used to access industrial timber production lands, recreational areas, and private land holdings. Access to the roads is via locked gates on JDSF property. Roads assessed in the LNFBR watershed include Roads 550, 555, and 561 in Berry Gulch, and Road 730 in Thompson Gulch.

Roads 550, 555 and 561 in the Berry Gulch subwatershed contain both rocked and unrocked segments. Types of stream crossings include culverted and filled crossings. Seventeen of the 30 culverted stream crossings have drainage structures not sufficiently designed for the 100-year peak storm flow, and 21 of the 30 total stream crossings inventoried show diversion potential because they lack critical dips. Comparable to roads in the HC watershed, poorly designed inboard ditches along marginally maintained roads are draining directly into stream crossings and hydrologically connected ditch relief culverts, thereby funneling fine sediment from the roads to the stream system. Most of the road network in the Berry Gulch assessment area is only accessible by ATV (quads).Some road segments can only be accessed on foot, including: (1) the southeast segment of Road 550 past site 103 where a large debris slide has obliterated the road; and (2) the northern segment of Road 555, north of site 127 and east of site 120.

Road 730 in the Thompson Gulch subwatershed consists entirely of unrocked native road. It is currently drivable. The road can be subdivided into two distinct sections: (1) the northwestern portion of the road in the upper watershed, which is mostly a full bench road traversing extremely steep hillsides consisting of small Class III stream crossings and dry swales; (2) the southeastern portion of the road, in the lower watershed, which is mostly streamside and includes considerably larger stream crossings and more hydrologically connected road segments. Types of stream crossings on Road 730 include culverted and filled crossings. All of the 5 culverted stream crossings have drainage structures not sufficiently designed for the 100-year peak storm flow, and all of the 7 stream crossings inventoried show diversion potential because they lack critical dips. Comparable to the Berry Gulch road network, poorly designed inboard ditches along marginally maintained roads are draining directly into stream crossings and hydrologically connected ditch relief culverts, thereby funneling fine sediment from the roads to the watershed’s streams.

5 FIELD TECHNIQUES AND DATA COLLECTION

The HC/LNFBR project consists of three distinct elements: (1) compilation of all known road, stream, and other pertinent maps; (2) a complete field inventory of all current and potential road related erosion sources along 15.2 mi of road; and (3) the development of a prioritized list of recommendations for cost-effective erosion control and erosion prevention treatments in the watershed.

For the first phase of the HC/LNFBR assessment, PWA acquired all pertinent JDSF, USGS, and CGS maps and GIS layers to document all roads and hydrologic features within the project area. These maps and data layers were used to generate field maps and identify known areas of geologic instability. Minor modifications to the field maps, based on actual field observations, were used to develop the GIS road layer for the final report maps. NAIP imagery included with Maps 2 and 3 was procured from the California Spatial Information Library (CaSIL, 2005).

For the second phase of the project, PWA completed a field inventory of roads in the HC/LNFBR area to identify all current and potential erosion sites related to the road network. Erosion sites, as defined in this assessment, include locations where there is direct evidence that current or future erosion or mass wasting, caused by or related to the road network, may deliver sediment to a stream channel. Sites of past erosion were not inventoried unless we determined that there was a potential for additional future sediment delivery. Furthermore, as the purpose of the inventory was to identify erosion sites with the potential to adversely impact fish-bearing streams, we excluded any erosion site that did not show evidence for delivering sediment to a stream channel, regardless of its evident potential for future erosion.

To carry out the field inventory, all roads (including both maintained and unmaintained routes) were walked and inspected by trained personnel, and all existing and potential erosion sites were identified. PWA personnel completed all aspects of the inventory, fieldwork, treatment prescriptions, data analysis, and reporting under the direction of a PWA licensed professional geologist.

Inventoried sites for this assessment primarily consist of stream crossings, springs generating sediment delivery, potential and existing landslides related to the road system, streamside bank erosion sites, gullies below ditch relief culverts, swales, and discharge points (e.g., roadside gullies, berm breaks, waterbars) for uncontrolled road surface and/or inboard ditch runoff. For each site identified as a potential erosion source, PWA staff plotted its location either on a 1:6,000 scale topographic or a GIS-generated base map, and recorded a series of field observations including (1) detailed site description, (2) nature and magnitude of existing and potential erosion problems, (3) likelihood of erosion or slope failure, (4) length of hydrologically connected road surface associated with the site, and (5) treatments needed for prevention or elimination of future sediment delivery. The data collected for each site also includes an evaluation of treatment immediacy, based on the potential or likelihood of sediment delivery from the site to stream channels in the watershed, and the level of urgency for addressing erosion problems at that location. Further, sites were evaluated for any unusual or complex issues, such as access problems or indications of imminent failure (see Section 6.2). Stream crossing sites were additionally evaluated for potential fish barrier problems.

For each existing or possible problem site in the project area, PWA geologists evaluated the potential for erosion and sediment delivery, and collected field measurements (length, width, and depth of the potential erosion area) to derive estimated sediment volumes. For most stream crossings, PWA field crews used tape and clinometer surveying techniques to develop longitudinal profiles and cross sections which were used to calculate road fill and potential sediment delivery volumes with the STREAM computer program. This proprietary software, developed for and by PWA, provides accurate and reproducible estimates of: (1) the potential volume of erosion at a stream crossing, whether over time, or during any possible catastrophic, storm-generated washouts; (2) excavation volumes associated with culvert installation, culvert replacement, or complete decommissioning of a stream crossing; and (3) backfill volumes associated culvert installation or replacement. In addition, field crews measured the lengths of hydrologically connected road segments to derive estimates for sediment delivery, on a decadal basis, using the empirical formula: (measured length) x (25 ft average width, including cutslopes and ditches) x (0.1-.3 ft average lowering of the road surface per decade). The value for road surface lowering was assigned by PWA staff in the field based on local geology as follows: (1) 0.1 ft/10 yr (low rating); (2) 0.15 ft/10 yr (moderate-low rating); (3) 0.2 ft/10 yr (moderate rating); (4) 25 ft/10 yr (moderate-high rating); and (5) 0.3 ft/10 yr (high rating).

Stream crossing culverts are sized to convey the 100-year peak storm flow as well as sediment and organic debris in transport. Where new or replacement stream crossing culverts are recommended for installation, PWA staff calculate the necessary culvert sizes using either (1) the Rational Method (Dunne and Leopold, 1978), for drainage areas less than 80 acres; or (2) for drainage areas larger than 80 acres, the empirical equations of the USGS Magnitude and Frequency Method (Wannanan and Crippen, 1977). These culvert sizing calculations are used for stream crossings where the field-estimated channel dimensions are greater than approximately 3 ft^2 cross sectional area.[4]

In the final phase of the project, PWA personnel analyzed the inventory results to develop cost-effective erosion control and erosion prevention prescriptions, as well as a prioritized plan of action for the project area. Using field observations, data analyses, and information from the landowner about realistic needs for future road usage, PWA staff assigned a treatment designation of either “upgrade” or “decommission” for each treatment site (Appendixes A, B). These designations are intended to provide the landowner with prescriptions and estimated costs for storm-proofing treatment sites and hydrologically connected road segments, and are our best recommendations for the most efficient and cost-effective methods to accomplish this goal.

6 RESULTS

6.1 Summary of Field Data and Analyses

PWA field crews identified a total of 166 sites and 13.6 mi of hydrologically connected road surfaces as having the potential to deliver sediment to streams in the HC/LNFBR assessment area (Maps 2, 3; Table 1a). We recommend that 162 of these sites and 13.5 mi of connected road segments be treated for erosion control and erosion prevention.

PWA recommends treatment for 75 stream crossings in the HC/LNFBR assessment area, which account for 46% of all treatment sites (Table 1a). Inventoried stream crossing sites include 51 crossings with culverts, 22 fill crossings, 1 Humboldt crossing, and 1 bridge. We project that approximately 17,975 yd^3 of future road related sediment delivery will originate from stream

[4]For stream channels with cross sectional areas of 3 ft^2 or smaller, PWA follows the recommendations outlined in the California Department Fish and Game *Salmonid Habitat Stream Restoration Manual* and defaults to a minimum culvert size of 24 in.

crossings if they are left untreated, which is approximately 57% of total future sediment delivery for the HC/LNFBR area (Table 2).

Table 1a. Inventory results for sediment delivery sites and hydrologically connected road segments, Noyo-Big River Watershed Management Plan Project, Part I: Jackson Demonstration State Forest, Mendocino County, California.

Sources of sediment delivery	Sediment delivery sites		Hydrologically connected roads adjacent to sites		Total length of roads surveyed for project (mi)
	Inventoried (#)	Recommended for treatment (#)	Inventoried (mi)	Recommended for treatment (mi)	
Stream crossings	75	75	7.0	7.0	-
Springs	10	10	0.4	0.4	-
Ditch relief culverts	43	43	5.0	5.0	-
Landslide	17	13	0.4	0.3	-
Bank erosion	13	13	0.3	0.3	-
Discharge points for road drainage	3	3	0.2	0.2	-
Other[a]	5	5	0.3	0.3	-
Total	**166**	**162**	**13.6**	**13.5**	**15.2**

[a]*Other* sources of sediment delivery are specified in Table 1b, and include: 3 gully diversions, and 2 swales.

Table 1b. Sediment delivery sites included in the “other” category in Table 1a and Maps 2 and 3, Noyo-Big River Watershed Management Plan Project, Part I: Jackson Demonstration State Forest, Mendocino County, California.

Site #	“Other” sediment delivery sites	Recommended for treatment (Y/N)
68	Gully diversion	Y
81.5	Gully diversion	Y
81.6	Gully diversion	Y
117	Swale	Y
174	Swale	Y

Table 2. Estimated future sediment delivery for sites and road surfaces recommended for treatment, Noyo-Big River Watershed Management Plan Project, Part I: Jackson Demonstration State Forest, Mendocino County, California.

Sources of sediment delivery	Estimated future sediment delivery (yd^3)	Percent of total
Stream crossings	17,975	57%
Springs	90	<1%
Ditch relief culverts	260	<1%
Landslides	1,265	4%
Bank erosion	1,675	5%
Discharge points for road surface drainage	20	<1%
Other sites[a]	135	<1%
Hydrologically connected road and cutbank surfaces adjacent to individual sediment delivery sites[b]	10,345	32%
Total	**31,765**	**100%**

[a]*Other* sources of sediment delivery are specified in Table 1b, and include: 3 gully diversions, and 2 swales.
[b]Sediment delivery for rocked and native surface roads is calculated for a 10 yr period. It assumes a combined width of 25 ft for the road, ditch, and cutbank contributing area, and 1 of 5 empirical values for road surface lowering and cutbank retreat based on field analyses by PWA staff: (1) 0.1 ft/10 yr (low rating); (2) 0.15 ft/10 yr (moderate-low rating); (3) 0.2 ft/10 yr (moderate rating); (4) 0.25 ft/10yr (high-moderate rating); and (5) 0.3 ft/10yr (high rating).

PWA identified 42 stream crossings on maintained and unmaintained roads that have drainage structures not sufficiently designed for the 100-year peak storm discharge (Table 3). Furthermore, of the 75 stream crossings, 57 have the potential to divert in the future and 27 streams are currently diverted. Of the 50 existing culverts at stream crossings, 23 have a moderate or high potential to become plugged by sediment and debris (Table 3).

Table 3. Erosion problems at stream crossings, Noyo-Big River Watershed Management Plan Project, Part I: Jackson Demonstration State Forest, Mendocino County, California.

Stream crossing problem	# Inventoried	% of total[a]
Stream crossings with diversion potential	57	75%
Stream crossings currently diverted	27	36%
Crossings with culverts likely to plug[b]	23	31%
Crossings with culverts that are currently undersized[c]	42	56%

[a]From Table 1, total stream crossings inventoried = 75.
[b]Culvert plug potential is moderate to high.
[c]Culverts in stream that are too small to convey the calculated 100-year peak storm flow. Of 50 existing culverts inventoried, 82% are undersized.

Field crews identified 17 potential road fill landslides, 13 of which are recommended for treatment (Table 1a). We project that approximately 1,265 yd^3 of future site-specific sediment delivery will originate from road fill landslides if they are left untreated, which is approximately 4% of total future sediment delivery for the HC/LNFBR area (Table 2).

A bank erosion site is the result of stream erosion at the base of road fill, as compared to a landslide site that includes other kinds of hillslope failure and initiation mechanisms. PWA all 13 inventoried bank erosion sites in the HC/LNFBR area for treatment (Table 1a). Estimated future sediment delivery for the 13 bank erosion sites is 1,675 yd^3.

Ditch relief culverts were designated as sites if they showed evidence for site-specific future erosion potential, were functioning as conduits for delivery of road surface sediment, or both. PWA inventoried a total of 43 ditch relief culverts, each of which is recommended for treatment. Ditch relief culverts represent 27% of all treatment sites, with a projected potential site specific sediment delivery of 260 yd^3 (Table 2).

PWA inventoried 10 springs, all of which are recommended for treatment. This is 6% of all treatment sites. Total estimated future sediment delivery for the 10 springs is 90 yd^3.

We inventoried 5 treatment sites of different types (3% of all treatment sites) that we classify as “other” sites. These include diversion gullies, and swales (Tables 1a, 1b). “Other” sites account for 135 yd^3 of future site-specific sediment volume in the HC/LNFBR area, or less than 1% of the total (Table 2). However, although these sites represent relatively low total sediment yield, they are potential conduits for future sediment delivery from hydrologically connected road surfaces and inboard ditches, and should be carefully considered for erosion control treatments.

PWA field crews measured approximately 13.6 mi of road surfaces and/or ditches (representing almost 90% of the total inventoried road mileage) currently draining to stream channels, either directly or via gullies (Table 1a). From these hydrologically connected road segments, we estimate that approximately 10,345 yd^3 of sediment (32% of total) could be delivered to stream channels within the HC/LNFBR area over the next decade if no efforts are made to change road drainage patterns (Table 2).

Of the 162 inventoried sites that we recommend for treatment, we designate 26 with priority ratings of high or high-moderate: 13 upgrade sites and 13 decommission sites (Map 3, Table 4). We project that, if left untreated, these 26 sites could deliver approximately 7,430 yd^3 of sediment to streams in the HC/LNFBR watersheds during the next decade. This is approximately 23% of projected sediment delivery for the HC/LNFBR area. We assign moderate or moderate-low priorities to 58 sites: 20 upgrade sites and 38 decommission sites. This represents approximately 15,400 yd^3 of the potential sediment delivery, or 49% of the total for the project area. Finally, we assign a low priority to 78 sites: 31 upgrade sites and 47 decommission sites. We estimate that implementing erosion control and erosion prevention for these sites could prevent approximately 8,935 yd^3 of sediment delivery to area streams, which is about 28% of the total for the project.

Table 4a. Treatment immediacy ratings for sediment delivery sites and associated lengths of hydrologically connected road, Noyo-Big River Watershed Management Plan Project, Part I: Jackson Demonstration State Forest, Mendocino County, California.

Treatment immediacy	UPGRADE		DECOMMISSION		Estimated future sediment delivery[b] (yd^3)	Percent of total
	Upgrade sites	Road length[a] (mi)	Decommission sites	Road length[a] (mi)		
High	4 Stream crossings	0.5	6 Stream crossings	0.8	3,915	12%
High-moderate	5 Stream crossings 4 Bank erosion	0.7	7 Stream crossings	0.6	3,515	11%
Subtotal	*13 sites*	*1.2*	*13 sites*	*1.4*	*7,430*	*23%*
Moderate	6 Stream crossings 1 Ditch relief culvert	0.5	10 Stream crossings 1 Ditch relief culvert 2 Landslides 3 Bank erosion 1 Other	1.8	9,770	31%
Moderate-Low	4 Stream crossings 5 Ditch relief culvert 1 Landslide 3 Bank erosion	0.8	10 Stream crossings 3 Springs 2 Ditch relief culverts 4 Landslides 1 Road surface 1 Other site	1.8	5,630	18%
Subtotal	*20 sites*	*1.3*	*38 sites*	*3.6*	*15,400*	*49%*
Low	10 Stream crossings 3 Springs 14 Ditch relief culvert 2 Bank erosion 1 Discharge point for road surface drainage 1 Other site	2.9	13 Stream crossings 4 Springs 20 Ditch relief culverts 6 Landslides 1 Bank erosion 1 Discharge point for road surface drainage 2 Other site	3.1	8,935	28%
Subtotal	31 sites	2.9	47 sites	3.1	8,935	28%
Total	**64 upgrade sites**	**5.4**	**98 decommission sites**	**8.1**	**31,765**	**100%**

*Note:*Individual treatment sites are shown on Map 3 and listed in Table 4b.
[a]*Road length* refers to hydrologically connected road reaches adjacent to recommended treatment sites. Roads recommended for maintenance in this report are not included in this table.
[b]*Estimated future sediment delivery* is the total delivery from treatment sites and any adjacent hydrologically connected road reaches.

Table 4b. Individual upgrade and decommission sites listed by type and treatment immediacy, Noyo-Big River Watershed Management Plan Project, Part I: Jackson Demonstration State Forest, Mendocino County, California.

Site type	Upgrade site ID #	Decommission site ID #
High treatment immediacy		
Stream crossings	133, 134, 139, 223	64, 89, 91, 143, 150, 194
High-moderate treatment immediacy		
Stream crossings	116, 131, 216, 217, 221	71, 76, 79.1, 84, 86, 120, 123
Bank erosion	139.8, 139.9, 222.1, 224.1	
Moderate treatment immediacy		
Stream crossings	108, 111, 118, 119, 138, 222	72, 77, 79, 80, 81, 88, 126, 127, 175, 190
Ditch relief culverts	112	67
Landslides		85, 168
Bank erosion		122, 147.5, 162
Other		81.6
Moderate-low treatment immediacy		
Stream crossings	135, 203, 214, 224	73, 74, 75, 82, 87, 124, 149, 151, 155, 195
Springs		78, 121, 145
Ditch relief culverts	110, 113, 115, 130, 220	65, 83
Landslides	186	61, 63, 151.5, 174.5,
Bank erosion	109, 212, 218	
Road surface		70
Other		68
Low treatment immediacy		
Stream crossings	137, 140, 142, 179, 185, 188, 204, 205, 207, 211	60.1, 153, 154, 160, 164, 165, 170, 173, 191, 196, 197, 200, 201
Springs	136, 141, 206	69, 144, 146, 158
Ditch relief culverts	132, 178, 180, 181, 182, 183, 187, 208, 209, 213, 215, 219, 225, 226	62, 90, 92, 147, 148, 152, 156, 157, 159, 161, 163, 166, 167, 172, 176, 192, 193, 198, 199, 202
Landslides		66, 104, 106, 107, 125, 169
Bank erosion	184, 210	171
Road surface	114	105
Other	117	81.5, 174

6.2 Unusually Problematic or Complex Sites or Road Segments

Several sites and areas are particularly noteworthy for their complexity, limited accessibility, or likelihood of delivering large volumes of sediment into the stream system. We project that 3 road segments will be difficult to maintain over the long-run because of their locations in narrow, confined stream valleys or their current limited access. Two stream crossings require upgrading from culverted crossings to bridges. Finally, at least 8 sites should be treated before the onset of winter storms to prevent imminent sediment delivery.

6.2.1 Sites with restricted access

Site 103 inhibits access to the eastern 800 ft of Road 550, which includes sites 100, 101, and 102 (Maps 2, 3). The site is a large landslide that has its upper extent and initiation point on the hillside above the road. The slide is a relatively deep (>10 ft) hillslope debris slide which has obliterated over 100 ft of the road alignment. The slide occurred on a very steep inner gorge hillside so there is no likelihood of locally bypassing it.

Another access problem is located at the stream crossing at Walton Gulch, where JDSF road crews are currently in the process of designing a bridge to replace the existing partially washed out culverted crossing. The crossing currently restricts access along Road 400 northwest of Bunker Gulch, and field observations indicate that there are several hundred feet of sediment stored behind the crossing in a broad valley bottom. As JDSF has already taken responsibility for upgrading the site, it is not included in the PWA inventory or database, but is flagged in the field as site 177.

6.2.2 Sites requiring immediate treatment

Based on field data and analyses, PWA recommends treating 8 sites in the HC/LNFBR before the onset of winter weather to avoid imminent sediment delivery:

1. Site 64, a large, complex stream crossing with a plugged culvert and multiple resulting diversions and fillslope failures. It is located on the south bank of Berry Gulch on Road 550, and besides showing evidence for imminent failure, is also restricting access to all travel (including ATV) northeast of the site.
2. Site 89 is located on the east bank of a major tributary to Berry Gulch, just north of the Road 555/tributary crossing. The site is a diverted stream channel causing road fill erosion directly into the tributary.
3. Site 91 is a large stream crossing on a large tributary to Berry Gulch which crosses Road 555 on the north side of Berry Gulch. The road fill at the crossing and associated adjacent fill within the crossing hingeline are actively eroding, representing approximately 1,842 yd^3 of potential sediment delivery.
4. Site 143, located on the northwest end of Road 400 in Hare Creek, has a separated pipe so that no flow is emerging from the outlet. As a result, the fill is failing because of fillslope saturation from the leaking culvert.
5. Site 150, also on Road 400, has a diverted stream with no drainage structure. The site area is saturated, increasing the likelihood of failure directly into Hare Creek at the base of the steep outboard fill.
6. Stream crossing site 223 is located directly above Bunker Gulch on the south end of Road 440.

The culvert is completely rusted through, and the outboard fill is actively failing directly into the stream.

7/8. Sites 222.1 and 224.1 are separate bank erosion sites on Bunker Gulch, caused by undercutting and erosion from the culvert outlets of stream crossing sites 222 and 224, respectively (Maps 2, 3). Sites 222 and 224 are recommended for upgrading from culverted crossings to bridges (section 6.2.3, below), but treatment for sites 222.1 and 224.1 should not be delayed until bridge installation.

6.2.3 Culverted stream crossings that need to be replaced with bridges

Sites 222 and 224 are large stream crossings on Road 440, which convey the Class I channel of Bunker Gulch under the road. Both culverts are in disrepair, undersized, poorly aligned, and are currently causing significant bank erosion downstream of their outlets. Based on drainage area calculations, bridges should be installed to replace the culverted crossings.

The main challenge at these sites will be the new bridge alignments. Road 440 was originally constructed directly adjacent and parallel to a confined channel. To maintain a relatively straight road useful for logging truck traffic, each culvert was aligned at a significant angle to the valley and flow direction of the channel, and this has resulted in significant bank erosion below the culvert outlets at both locations. The new bridges will also have to be installed at an angle to the channel, because constructing either bridge so that it is aligned with the existing channel would take a prohibitively long span. Constructing the bridges askew to the channel will require the bridge abutments to be fortified with rock armoring, and the channel reaches immediately upstream and downstream of the sites will need to be protected with rock armor in such a way as to protect the stream banks without exacerbating downstream erosion. The estimated length for each bridge is a minimum of 60 ft to span the estimated 45 ft between the ends of the road after excavation.

Partial costs for installing the 2 bridges and treating the sites are $40,380 for site 222 and $41,970 for site 224. These are preliminary totals, and do not include the costs for move in/move out time, layout and supervision, permitting, road drainage, or purchasing the bridges. Items included in these totals are: (1) equipment times for excavator and bulldozer to excavate the existing road fill, and dump truck time for hauling fill to a spoil site;. (2) excavator time for rock placement to construct rock armored abutments; (3) bridge installation time for excavator, bulldozer, and labor; (4) additional labor time for spreading mulch; (5) materials costs for mulch and delivered rock; (6) logistics costs. PWA estimates that upgrading the sites will prevent delivery of 560 yd^3 of sediment from site 222, and 530 yd^3 from site 224, to Bunker Gulch during the next decade. It may also facilitate juvenile fish passage at the sites.

6.2.4 Sites with unusually complex treatment requirements

Site 88 is noteworthy because it has a series of skid roads above it which are currently diverting flow above the existing crossing, and show the potential to continue to do so in the future. There are multiple channels above this crossing, with numerous headcuts and significant gullying. When this site is decommissioned, PWA recommends channelizing up to and beyond the skids to create a more stable channel configuration above the inboard road.

Sites 80, 81, 82, and 83 (stream crossings), and sites 81.5 and 81.6 (gully diversions) are located in the area of a large deep seated landslide that encompasses Road 550 in the upper reaches of Berry Gulch. This complex landslide has been previously identified by the California Geologic Survey (Braun et al., 2005; also see Appendix D). A large number of hillside skids exacerbate the effects the landslide is having on the road. Both the landslide and the skid roads cause channel diversions on the hillsides between the switchback portions of the road. These channel diversions have essentially rerouted the natural hillside streamflow patterns creating gullies, headcuts, and enlarged channels throughout the area. This section of road is slated for decommissioning, and we suggest that, during implementation, JDSF assess the possibility of treating some of the local skid network on the hillsides between switchbacks which were outside the scope of this project.

6.2.5 Roads with unusually complex maintenance issues

Road 440 and the segment of Road 400 in Covington Gulch are built adjacent to confined channels, and constructed so close to the channels that their fillslopes tend encroach upon the channels and make up the channel margins. This alignment configuration is resulting in abundant bank erosion sites along the roads. The valleys are too narrow to relocate the roads further from the channels, and according to JDSF road maintenance personnel, there are currently no alternative road routes available to bypass these inherently unstable sections of road. PWA personnel identified multiple current and past bank erosion sites along these road segments and have prescribed treatments for them (Maps 2, 3; Appendix B), but without the ability to significantly change the road alignments, there is little doubt that new bank erosion sites will develop in the future. PWA strongly recommends that, as long as they remain in use, JDSF undertake regular maintenance to address bank erosion and sediment delivery on these road reaches, including clearing existing channel obstructions to reduce the likelihood of flow deflection.

7 RECOMMENDED TREATMENTS

PWA recommends 21 different types of erosion control and erosion prevention treatments for the HC/LNFBR project area, which we generally subdivide into 2 categories: site-specific treatments and road surface treatments (Table 5). These prescriptions include both upgrading and decommissioning measures.

Stream crossing treatments are primarily implemented to reduce the risk of catastrophic failure and sediment delivery resulting from erosion of road fill or stream diversion along road surfaces. Recommended treatments for stream crossings include: (1) constructing a total of 19 critical dips to prevent diversions at streams with diversion potential; (2) installing 7 culverts at currently unculverted stream crossings; (3) replacing 12 undersized or damaged culverts; and (4) constructing 5 armored fill crossings. In addition, installation of a trash rack is required for 1 stream crossing culvert; 1 culvert requires cleaning to fix a blocked inlet; and 2 sites require bridges.

Table 5. Recommended treatments for inventoried sites and road surfaces, Noyo-Big River Watershed Management Plan Project, Part I: Jackson Demonstration State Forest, Mendocino County, California.

Treatment type			No.	Comments
Site specific treatments	Stream crossing treatments	Culvert (install)	7	Install a culvert at an unculverted fill (Site # 108, 111, 133, 134, 179, 205, 217)
		Culvert (replace)	12	Replace an undersized, poorly installed, or worn out culvert (Site # 116, 119, 131, 135, 137, 138, 139, 185, 203, 204, 207, 223).
		Clean / clear culvert	1	Remove sediment or debris from the culvert (Site # 132).
		Trash rack	1	Install at culvert inlets to prevent plugging (Site # 185).
		Wet crossing	5	Install armored fill crossings (Site # 118, 211, 214, 216, 221) using 115 yd^3 of rock armor.
		Install bridge	2	Install bridge at undersized drainage structure or for fish passage (Site # 222, 224).
		Critical dip	19	Install to prevent stream diversions (Site # 108, 111, 116, 117, 131, 133, 135, 137-140, 179, 185, 203-205, 207, 217, 223).
	Other	Rock (armor)	49	At 49 sites, add a total of 1,505 yd^3 of rock armor on inboard and outboard stream crossing fillslopes, ditches, and headcuts (Site # 68, 75, 76, 79, 80, 108, 109, 112-116, 119, 120, 123, 124, 126, 131-133, 135, 137, 139, 140, 153, 154, 164, 170, 173, 185, 203-208, 210, 211, 213, 216-219, 221-224.1).
		Soil excavation	128	At 128 sites, excavate and remove a total of 39,235 yd^3 of sediment, primarily at fillslopes and stream crossings (Site # 60.1, 61-79, 79.1, 80, 81, 81.5, 81.6, 82-92, 104, 106-109, 111, 113, 114, 116-127, 134, 135, 138, 139.8, 139.9, 143-147, 147.5, 148-151, 151.5, 152-173, 174.5, 175, 176, 179,184, 186, 190-202, 205, 210-214, 216-218, 221, 222, 222.1,223,224,224.1)
		Miscellaneous treatments	8	Miscellaneous treatments at 8 site-specific locations (Site # 108, 115, 133, 139.8, 139.9, 210, 223, 226)
Road surface treatments	Road drainage structures	Ditch relief culvert (install or replace)	74	Install or replace ditch relief culverts to improve road surface drainage.
		Ditch relief culvert downspout	3	Install to prevent erosion at ditch relief culvert outlets
		Rolling dip	92	Install to improve road drainage.
		Off-road drain	28	Install to improve road drainage.
		Cross road drain	770	Install to improve drainage on decommission roads
	Road shaping treatments	Outslope road and remove ditch	84	At 84 locations, outslope road and remove ditch for a total of 39,135 ft of road to improve road surface drainage
		Outslope road and retain ditch	31	At 31 locations, outslope road and retain ditch for a total of 12,115 ft of road to improve road surface drainage
		Berm (remove)	4	At 4 locations, remove a total of 285 ft of berm to improve road surface drainage.
		Clean or cut ditch	3	At 3 locations, clean or cut ditch for a total of 2,280 ft
		Remove ditch	1	At 1 location, remove ditch for a total of 20 ft
	Other	Road rock (for road surfaces)	3	At 3 locations, use a total of 70 yd^3 of road rock to rock the road surface at 1 stream culvert installation, 1DRC installation, and 1 armored fill.

Road treatments are designed to control road drainage by reshaping the roadbed, which redirects concentrated flow to stable slopes and prevents delivery to streams. Upgrading treatments to redirect flow include outsloping the road, installing rolling dips, cutting ditches, and removing berms. Road surface erosion is curtailed by adding road rock, which fortifies the surface and reduces production of fine sediment. For road decommissioning, frequent cross-road drains are proposed to direct water off road and skid surfaces.

Road treatments in the project area include: (1) removing a total of approximately 285 ft of outboard road berm; (2) cleaning/cutting 2,280 ft of ditch (3) removing 20 ft of ditch, (3) outsloping a total of 51,250 ft of road (outsloping at retaining ditch for 12,115 ft; outsloping and removing ditch for 39,135 ft), (4) installing 92 rolling dips and, (5) adding a total of 70 yd3 of road rock at 3 locations.

Once the road shaping and road drainage structures have been constructed, most sections of the road will need to be watered and recompacted as a final road treatment. Following the completion of all construction and road rocking, bare soil areas should be seeded with native grasses appropriate for the area. Where necessary, bare soil areas should be mulched with weed-free straw to prevent sediment delivery to nearby gullies or streams.

8 HEAVY EQUIPMENT AND LABOR REQUIREMENTS

Equipment needs for erosion control treatments in the assessment area are detailed in the project database and summarized, based on immediacy, in Table 6. Most treatments require the use of heavy equipment, e.g., excavator, bulldozer, grader, and water truck. Some hand labor is required at sites needing downspouts, new culverts or culvert repairs, or for applying seed and mulch to ground disturbed during construction. Equipment needs are reported as equipment times, in hours, to treat all sites and road segments. These estimates only include the time needed for the actual treatment work, and do not include activities categorized as logistics, such as travel time between work sites, or the time needed for work conferences at each site. Work hours tallied under logistics are added to the hours needed for the actual treatment work to determine total equipment costs (Table 7).

PWA estimates that erosion control and erosion prevention remediation in the HC/LNFBR area will require 1,413 hr of excavator time and 1,402 hr of bulldozer time (Table 6). An excavator and bulldozer will not be needed at all treatment sites, and some treatment sites will require one but not the other. Dump truck operators will require 1,221 hrs to transport excavated spoil material to disposal sites. Approximately 152 hr of water truck time will be needed for applying water to dry soils during road-drainage treatment implementation, and for backfilling excavations at stream crossings and ditch relief culverts. Finally, approximately 400 hr of labor time will be required for various tasks, including culvert installation or replacement. Construction activities such as opening roads, staging materials at work sites, traveling between sites, final grading, and spreading road rock, straw, and mulch require equipment and labor hours in addition to those listed above. These additional needs are described in detail in Table 7.

Table 6. Estimated heavy equipment and labor requirements based on treatment immediacy, Noyo-Big River Watershed Management Plan Project, Part I: Jackson Demonstration State Forest, Mendocino County, California.

Treatment immediacy	# of sites	Excavated volume[a] (yd^3)	Excavator (hr)	Bulldozer (hr)	Dump truck (hr)	Water truck (hr)	Labor (hr)
High or high-moderate	26	11,955	386	368	383	36	77
Moderate or moderate-low	58	22,235	636	673	685	52	166
Low	78	8,560	391	361	153	64	157
Total	**162**	**42,750**	**1,413**	**1,402**	**1,221**	**152**	**400**

Note: Equipment and labor times do not include hours necessary for opening roads, traveling between sites, and spreading straw and mulch.

[a]Excavated volume includes material permanently removed and stored as well as material excavated and reused for backfilling upgraded stream crossings.

Approximately 400 hr of labor time will be required for various tasks, e.g., installing culverts, trash racks, and downspouts (Table 6), and an additional 793 hr of labor time are needed for spreading straw mulch and seed (Table 7, footnote “i”). In addition, 32 hrs of truck/trailor time will be needed for delivering straw and culverts to work sites (Table 7, footnote “g”). Approximately 44 hrs will be required by motor graders to create a “finished” grade to banks, ditches, and road surfaces following rough construction by other equipment (e.g., excavators and bulldozers).

9 ESTIMATED COSTS

The estimated total cost to implement the recommended erosion control and erosion prevention treatments for the HC/LNFBR area is $1,5758,190 (Table 7). Approximately $221,670, or 14 % of the total, is for the purchase of rock and culvert materials. A total of $254,000 is projected for detailed project planning, on-site equipment operator instruction and supervision, establishing effectiveness monitoring measures, and post-project analysis and reporting. There will also be necessary expenses for the use of lowboy trucks to haul construction equipment to and from the work area.

The costs in Table 7 are based on a number of assumptions and estimates, and many of these are included as footnotes to the table. The costs provided are assumed reasonable if work is performed by outside contractors, and there is no added overhead for contract administration and pre- and post-project surveying.

Table 7. Estimated equipment times and costs to implement erosion control and erosion prevention treatments, Noyo-Big River Watershed Management Plan Project, Part I: Jackson Demonstration State Forest, Mendocino County, California.

Cost category[a]		Cost rate[b] ($/hr)	Estimated Project Times			Total estimated costs[e] ($)
			Treatment[c] (hr)	Logistics[d] (hr)	Total (hr)	
Move in, move out[f]	Excavator	140	40	--	40	5,600
	Bulldozer	140	40	--	40	5,600
	Grader	140	40	--	40	5,600
	Water Truck	125	16	--	16	2,000
	Truck / trailer	70	32	--	32	2,240
Road opening	Excavator	238	20	--	20	4,760
	Bulldozer	148	20	--	20	2,960
Heavy equipment for site-specific treatments[g]	Excavator	238	1,133	340	1,473	350,580
	Bulldozer	148	1,009	303	1,312	194,180
	Dump truck	123	1,221	366	1,587	195,210
	Roller	128	6	2	8	1,030
	Water truck	125	41	12	53	6,630
	Truck / trailer	70	75	23	98	6,860
Heavy equipment for road drainage treatments[h]	Excavator	238	312	94	406	96,630
	Bulldozer	148	393	118	511	75,630
	Roller	128	60	18	78	9,990
	Water truck	125	145	44	189	23,630
	Grader	145	34	10	44	6,380
Laborers[i]		78	610	183	793	61,860
Rock costs (includes trucking for 70 yd^3 of road rock and 1,620 yd^3 of riprap)						110,770
Culvert materials costs (2,625’ of 18”, 750’ of 24”, 105’ of 30”, 240’ of 36”, 50’ of 42, and 60’ of 48, including costs for couplers and elbows)						110,900
Mulch, seed, and planting materials for 10.4 acres of disturbed ground[j]						7,150
Permitting						25,000
Miscellaneous costs						10,000
Supervision, coordination, layout, and reporting[k]						254,000
Total Estimated Costs: $1,575,190						
Potential sediment savings: 31,765 yd^3						

(Continued on next page.)

Table 7—continued.

[a]Costs excluded from the list are for (1) tools and miscellaneous materials, and (2) variable administration and contracting expenses.

[b]Heavy equipment costs include operator and fuel. Costs listed are estimates for favorable local private sector equipment rental and labor rates.

[c]Treatment times refer to equipment hours expended explicitly for erosion control and erosion prevention work at all project sites and roads.

[d]Logistics times for heavy equipment (30%) include all equipment hours expended for opening access to sites on maintained and abandoned roads, travel time for equipment to move from site to site, and conference times with equipment operators to convey treatment prescriptions and strategies. Logistic times for laborers (30%) include estimated daily travel time to project area.

[e]Total estimated project costs for equipment rental and labor are based on private sector rates at prevailing wage. Materials costs are subject to change.

[f]Lowboy hauling costs area based on 2 hauls each (1 to move in and 1 to move out) at 10 hr/ trip, per watershed per operating, for excavator, bulldozer, grader, and water truck.

[g]An additional 44 hr of truck / trailer time are added for delivering straw to sites. A total of 31 hr of truck and trailer time are added for delivering culverts.

[h]An additional 34 hr of water truck time and 34 hr of grader time are added for final grading and spreading road rock.

[i]An additional 207 hr of labor time are added for spreading straw mulch and seeding. This includes 44 hr of labor for initial delivery of straw to sites.

[j]Seed costs are based on 357 lb of native seed per acre at $9.75/lb. Straw needs are 50 bales per acre at $6.95/bale. Labor time for straw mulching and seeding is 163 hr.

[k]Supervision time includes detailed layout (flagging, etc) prior to equipment arrival, training of equipment operators, supervision during equipment operations, supervision of labor work, and post-project documentation and reporting.

Most of the treatments listed in this plan are not complex or difficult for equipment operators with experience in road upgrading and decommissioning operations on forestlands. The use of inexperienced operators or the wrong combination of heavy equipment would require additional technical oversight and supervision in the field, as well as an escalation of the costs to implement the work. To help insure success of the project, it is imperative that the project coordinator be on-site full time at the beginning of the project and intermittently after equipment operations have begun.

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APPENDIX A
Supplementary information regarding terminology and techniques used in road related erosion assessments

A-1 SOURCES OF ROAD RELATED EROSION

Sources for erosion and sediment delivery in the assessment area are divided into two categories: (1) sediment from specific treatment sites, and (2) sediment from the surfaces of road segments of varying lengths—and their associated cutbanks and inboard ditches—that are hydrologically connected[1] to streams.

A-1.1 Site-Specific Erosion Sources

A-1.1.1 Stream crossings

A *stream crossing* is a ford or structure on a road (such as a culvert or bridge) installed across a stream or watercourse (USDA Forest Service, 2000). When they erode, sediment delivery from stream crossings is always assumed to be 100%, because any sediment eroded is delivered directly to the stream. The size of the stream affects the rate of sediment movement, but any sediment delivered to small ephemeral streams will eventually be transported to downstream fish-bearing stream channels.

Common features of stream crossings that lead to erosion problems include (1) fill crossings without culverts, (2) crossings with undersized culverts, (3) crossings with culverts susceptible to being plugged, (4) crossings with logs or debris buried in the fill intended to convey streamflow (i.e., *Humboldt crossings*), (5) crossings with a potential for stream diversion, and (6) crossings that have currently diverted streams.

A *fill crossing* is a stream crossing without a culvert to carry the flow through the road prism. At such sites, stream flow either crosses the road and flows over the fillslope, or is diverted down the road via the inboard ditch. Most fill crossings are located at small Class II or III streams that only have flow during larger runoff events. *Armored fill crossings* and *ford crossings* are similarly designed to be functional, unculverted stream crossings. A properly constructed armored fill crossing is based on a site-specific design, using a mix of riprap-sized rock to minimize erosion while allowing the stream to flow across the road prism. A ford crossing may use rock armor to stabilize the roadway, but the road is built essentially on the natural stream channel, and fill is not used.

Humboldt crossings are constructed from logs or woody debris, usually laid parallel to flow, which are then covered with fill. Humboldt crossings are susceptible to plugging, gullying, and washout during storm flows (Weaver et al., 2006). Older Humboldt log crossing structures beneath more recently installed culverts are often found in rural northern California road networks.

Large volumes of erosion may occur at stream crossings when culverts are too small for the drainage area and storm flows exceed culvert capacity, or when culverts become plugged by sediment and debris. In these instances, flood runoff will spill across the road, allowing erosion

[1] *Hydrologically connected* describes sites or road segments from which eroding sediment is delivered to stream channels (Furniss et al., 2000).

of the stream crossing fill and development of a *washout crossing*. Washout crossings will remain highly problematic as the stream banks continue to erode to a natural grade.

Serious erosion problems may occur at a stream crossing that has a high *diversion potential*, which means that flow is diverted down the road, either on the roadbed or in the ditch, instead of spilling over the fill and back into the same stream channel. In this case, the roadbed, hillslope, and/or stream channel that receive the diverted flow may become deeply gullied or destabilized. As road and hillslope gullies enlarge over time, they will deliver increasingly greater quantities of sediment to stream channels (Hagans et al., 1986), and streamflow diverted onto steep, unstable slopes may trigger hillslope landslides.

To be considered adequately sized, culverts at stream crossings must be able to convey a 100-year peak storm flow[2] as well as sediment and organic debris in transport during high flows (Weaver et al., 2006). Undersized culverts do not have the capacity to convey stream flow during periods of heavy rainfall, and are susceptible to plugging by sediment and debris. Many stream crossing culverts in the project area are substandard, i.e., are not large enough to convey a 100-year flow, or are installed at too low a gradient through the stream crossing fill to prevent plugging. Improper culvert installations such as these were once common because they required shorter lengths of pipe to convey flow through the road, and were therefore used to minimize construction costs. However, in the long run these cost-cutting measures prove detrimental to erosion control and maintenance costs because the culvert discharges water onto unconsolidated road fill, rather than into the pre-existing stream channel, which results in pronounced erosion of the outboard, downstream fill face.

A-1.1.2 Ditch relief culverts

A *ditch relief culvert* (DRC) is a plastic, metal, or concrete pipe installed beneath the road surface to convey flow from an inside road ditch to an area beyond the outer edge of the road fill. When properly spaced, DRCs limit the quantity of water available to cause erosion at any single location, allowing flow to disperse and reducing the likelihood of gullies forming at their outlets. It is sometimes necessary to install downspouts or rock armor at DRC outlets to further disperse energy and prevent erosion.

A-1.1.3 Landslides

Landslides with the potential to fail during periods of high and prolonged rainfall events are identified in the field by tension cracks, scarps showing vertical displacement, corrective regrowth on trees (i.e., pistol butt trees) and perched, hummocky fill indicating surface instability. As a standard practice, PWA maps all landslides observed in the field, but only Inventories those that are associated with roads and show a potential to deliver sediment to a watercourse. Types of landslides in a road related erosion assessment typically include (1) road fill failures, (2) landing fill failures, (3) hillslope debris slides, and (4) deep-seated, slow landslides. The majority of treatable landslides in an assessment area are often the result of failure of unstable fill and sidecast material from earlier road construction. Preemptive

[2] The *100-year peak storm flow* for a location is the discharge that has a 1% probability of occurring at that location during any given year.

excavation of small, current or potential landslides is an effective technique for erosion control, achieved by removing the eroding material and redepositing it in a stable, designated location either at or near the treatment site. Conversely, large, deep-seated landslides are usually technically infeasible to treat.

A-1.1.4 Additional site-specific sediment sources

Additional, typically less frequent sources of sediment delivery include: (1) discharge points for road surface, cutbank, and ditch erosion; (2) point source springs; (3) sites of bank erosion; (4) swales; (5) channel scour; and (6) non-road related upslope gullies.

Unpaved road surfaces, and their associated cutbanks and inboard ditches, are major sources for erosion and delivery of fine sediment to stream channels. Road surface, cutbank, and ditch erosion is termed “chronic” because it occurs throughout the year, and may include one or more of the following processes: (1) mechanical pulverizing and wearing down of road surfaces by vehicular traffic; (2) erosion of unpaved road surfaces by rainsplash and runoff during periods of wet weather; (3) erosion of inboard ditches by runoff during wet weather; and (4) erosion of cutbanks by dry ravel, rainfall, slope failures, and brushing/grading practices. *Discharge points for road surface, cutbank, and ditch erosion* are locations where sediment-laden flow from poorly drained road/cutbank/ditch segments exits the roadway to be delivered into the stream system. Discharge points are often in the form of roadside gullies or water bars, but on some low gradient or streamside roads may simply be low spots where concentrated flow exits the road and is delivered directly into a stream without gully formation.

Point source springs refer to sites where spring flow is entering the roadbed and causing erosion. Flow from multiple springs may become concentrated along a road with inadequate drainage structures, creating roadside gullies or fillslope failures. *Swales* are channel-like depressions that only carry minor flow during periods of extreme rainfall. *Bank erosion* sites refer to locations of streambank erosion caused or exacerbated by emplacement of a nearby road. *Non-road related upslope gullies* are sites of focused runoff channeled from upslope areas during high discharge.

A-1.2 Evaluation of Hydrologically Connected Road Segments

PWA measures the lengths of hydrologically connected road segments adjacent to sediment delivery sites, such as on either side of a stream crossing, ditch relief culvert, or discharge point, to derive an estimate for total potential sediment delivery from connected road surfaces in the project area. In addition, because the adjacent hydrologically connected road segments contribute to the overall erosion and sediment delivery problem at a site, PWA considers the treatment site and adjacent road segments as a unit when estimating future sediment delivery and developing treatment prescriptions for that location.

A-2 OVERVIEW OF STORM-PROOFING ROADS (ROAD UPGRADING AND DECOMMISSIONING)

Forest and rural roads may be storm-proofed by one of two methods: upgrading or decommissioning (Pacific Watershed Associates, 1994; Weaver and Hagans, 1999; Weaver et al., 2006). Upgraded roads are kept open, and are inspected and maintained. Their drainage facilities and fills are designed or treated to accommodate the 100-year peak storm flow[3]. Conversely, properly decommissioned roads are closed and no longer require maintenance. Whether through upgrading or decommissioning, the goal of storm-proofing is to make the road as “hydrologically invisible” as possible, that is, to reduce or prevent future sediment delivery to the local stream system. A well-designed storm-proofed road includes specific characteristics (Table A1), all proven to contribute to long-term improvement and preservation of watershed hydrology and aquatic habitat.

A-2.1 Road upgrading

Road upgrading involves a variety of treatments used to make a road more resilient to large storms and flood flows. The most important of these include upgrading stream crossings (especially culvert upsizing to accommodate the 100-year peak storm flow and debris in transport, and correct or prevent stream diversion); removing unstable sidecast and fill materials from steep slopes; and applying road drainage techniques (e.g., installing ditch relief culverts, removing berms, constructing rolling dips, insloping or outsloping the road) to improve dispersion of surface runoff. Road upgrading usually also includes adding road rock or riprap as needed to fortify roads and crossings.

A-2.1.1 Installing rolling dips

Rolling dips are installed on low- to moderate-gradient hydrologically connected[4] roads to disperse surface runoff and discharge it onto native hillslope below the road. Rolling dips extend from the inboard edge to the outboard edge of a road, and are constructed at intervals as needed to control erosion (typically 100, 150, or 200 ft). They are effective in reducing year-round (“chronic”) sediment delivery from road surfaces, and are designed to be easily drivable and not impede vehicular traffic.

A-2.1.2 Road shaping

Road shaping changes the existing geometry or orientation of the road surface, and is accomplished through insloping (sloping the road toward the cutbank), outsloping (sloping the road toward the outside edge), or crowning (creating a high point down the center axis of the road so that it slopes equally inward and outward). Like rolling dips, road shaping is used to prevent uncontrolled delivery of road surface runoff by dispersing it into the inside ditch or onto the hillslope below the road. This is also effective in preventing the formation of gullies at the edge of the road, and localized slope instability below the road.

[3] The *100-year peak storm flow* for a location is the discharge that has a 1% probability of occurring at that location during any given year.
[4] *Hydrologically connected* describes sites or road segments from which eroding sediment is delivered to stream channels (Furniss et al., 2000).

Table A1. Characteristics of storm-proofed roads (*from* Weaver et al., 2006).

Storm-proofed stream crossings

- All stream crossings have a drainage structure designed for the 100-year peak storm flow (with debris).
- Stream crossings have no diversion potential (functional critical dips are in place).
- Stream crossing inlets have low plug potential (trash barriers installed).
- Stream crossing outlets are protected from erosion (extended beyond the base of fill; dissipated with rock armor).
- Culvert inlet, outlet, and bottom are open and in sound condition.
- Undersized culverts in deep fills (greater than backhoe reach) have emergency overflow culvert.
- Bridges have stable, non-eroding abutments and do not significantly restrict 100-year flood flow.
- Fills are stable (unstable fills are removed or stabilized).
- Road surfaces and ditches are "hydrologically disconnected" from streams and stream crossing culverts.
- Class I stream crossings meet CDFG and NMFS fish passage criteria (Taylor and Love, 2003).

Storm-proofed fills

- Unstable and potentially unstable road and landing fills are excavated or structurally stabilized.
- Excavated spoil is placed in locations where it will not enter a stream.
- Excavated spoil is placed where it will not cause a slope failure or landslide.

Road surface drainage

- Road surfaces and ditches are "hydrologically disconnected" from streams and stream crossing culverts.
- Ditches are drained frequently by functional rolling dips or ditch relief culverts.
- Outflow from ditch relief culverts does not discharge to streams.
- Gullies (including those below ditch relief culverts) are dewatered to the extent possible.
- Ditches do not discharge (through culverts or rolling dips) onto active or potential landslides.
- Decommissioned roads have permanent drainage and do not rely on ditches.
- Fine sediment contributions from roads, cutbanks, and ditches are minimized by utilizing seasonal closures and implementing a variety of surface drainage techniques including berm removal, road surface shaping (outsloping, insloping, or crowning), road surface decompaction, and installing rolling dips, ditch relief culverts, waterbars, and/or cross-road drains to disperse road surface runoff and reduce or eliminate sediment delivery to the stream.

A-2.1.3 Installing ditch relief culverts

A ditch relief culvert is a drainage structure (usually an 18 in. pipe) installed across a road prism to move water and sediment from the inboard ditch so that it can be dispersed on native hillslope beneath the road. Ditch relief culverts are used to drain ditch flow on roads that are too steep for rolling dips or outsloping, as well as at sites with excessive flow from springs or seepage from cutbanks.

A-2.1.4 Excavating unstable fillslope

The fillslope, the sloping part of the road between its outboard edge and the natural ground surface below, may fail or show signs of potential failure. As a preventative measure, unstable fillslope sediment is excavated and relocated to a permanent, stable spoil depository site.

A-2.1.5 Upgrading stream crossings

Techniques used to remediate road related erosion at a stream crossing are dependent on the size of the stream channel, and specific physical characteristics at the crossing site. Class I and large stream crossings may require a bridge, or, if their banks are small or low gradient, a ford crossing may be suitable, particularly if seasonal use is anticipated. A common approach to upgrading moderate sized Class II and III crossings is to construct a culverted fill crossing capable of withstanding the 100-year flood flow. Techniques for upgrading small stream crossings include:

Installing or replacing culverts. A culvert capable of withstanding the 100-year storm flow, including expected sediment and debris, is installed or replaced in the fill crossing. Culverts on non fish-bearing streams are placed at the base of fill, in line and on grade with the natural stream channel upstream and downstream of the crossing site. Backfill material, free of woody debris, is compacted in 0.5-1.0 ft thick lifts until 1/3 of the diameter of the culvert has been covered. At sites where fillslopes are steeper than 2:1, or where eddying currents might erode fill on either side of the inlet, rock armor is applied as needed.

Installing an armored fill. Armored fills are installed on smaller stream crossings with relatively small fill volume, but where debris torrents are common, channel gradients are steep, or inspection and maintenance of a culverted crossing is impossible. The roadbed is heavily rocked, and a keyway in the outboard fillslope is excavated and backfilled with interlocking rock armor of sufficient size to resist transport by stream flow. Armored fill crossings are constructed with a dip in the axis of the crossing to prevent diversion of the stream flow, and focus the flow over the part of the fill that is most densely armored.

Installing secondary structures. A variety of secondary structures may be used to increase the function of small stream crossings by allowing uninterrupted stream flow, decreasing flooding, and controlling erosion. Where a culvert has been improperly installed too high in the fill, a *downspout* may be added to its outlet to release the flow close to the ground surface, rather than letting it cascade from the height of the culvert. *Rock armor* may be used to buttress steep fillslopes, as well as to prevent erosion of inboard or outboard fillslopes by eddying currents. A *trash rack* placed in the channel above a culvert inlet will trap debris and reduce plugging. To prevent stream diversion should the culvert become plugged or its capacity exceeded, a *critical dip* (essentially a rolling dip constructed in line with the stream channel) may be installed to ensure that stream flow will be directed across the road and back into the natural channel. Finally, an *overflow culvert* may be a necessary addition at a culverted crossing where, because of site conditions, plugging or capacity exceedence of the primary culvert is anticipated.

A-2.2 Road decommissioning

In essence, decommissioning is “reverse road construction”, although complete topographic obliteration of the roadbed is not usually required to achieve cost-effective erosion prevention. In most cases, serious erosion problems are confined to a few, isolated locations along a road (perhaps 10% to 20% of the full road network to be decommissioned) where stream crossings need to be excavated, unstable sidecast on the downslope side of a road or landing needs to be removed before failure, or the road crosses unstable terrain and the entire road prism must be removed. But typically, lengths of road beyond the extent of individual treatment sites usually require simpler, permanent improvements to surface drainage, such as surface decompaction, additional road drains, and/or partial outsloping. As with road upgrading, the heavy equipment techniques used in road decommissioning have been extensively field tested, and are widely accepted (Weaver and Sonnevil, 1984; Weaver and others, 1987, 2006; Harr and Nichols, 1993; Pacific Watershed Associates, 1994).

A-2.2.1 Road ripping or decompaction

Road ripping is a technique in which the surface of a road or landing is disaggregated or "decompacted" to a depth of at least 18 in.using mechanical rippers. This action reduces or eliminates surface runoff and usually enhances revegetation.

A-2.2.2 Installing cross-road drain

Cross-road drains (also called “deep waterbars”) are large ditches or trenches excavated across a road or landing surface to provide drainage and prevent runoff from traveling along, or pooling on, the former road bed. They are typically installed at 50, 75, 100 or 200 ft intervals, or as necessary at springs and seeps. In some locations (e.g., streamside zones), partial outsloping may be used instead of cross-road drain construction.

A-2.2.3 In-place stream crossing excavation (IPRX)

IPRX is a decommissioning treatment used for roads or landings that are built across stream channels. The fill (including the culvert or Humboldt log crossing) is completely excavated and the original streambed and side slopes are exhumed. Excavated spoil is stored at nearby, stable locations where it will not erode. In some cases, this may necessarily be as far as several hundred feet from the crossing. An IPRX typically involves more than simply removing a culvert, as the underlying and adjacent fill material must also be removed and stabilized. As a final measure, the sides of the channel may be cut back to slopes of 2:1, and mulched and seeded for erosion control.

A-2.2.4 Exported stream crossing excavation (ERX)

ERX is a decommissioning treatment in which stream crossing fill material is excavated and the spoil is hauled off-site for storage (the act of moving spoil material off-site is called “endhauling”). This procedure is necessary when large, stable storage areas are not available at or near the excavation site. It is most efficient to use dump trucks to endhaul the spoil material.

A-2.2.5 In-place outsloping (IPOS)

IPOS (also called "pulling the sidecast") calls for excavation of unstable or potentially unstable sidecast material along the outside edge of a road prism or landing, and placement of the spoil on the roadbed against the corresponding, adjacent cutbank or within several hundred feet of the site. As a further decommissioning measure, the spoil material is placed against the cutbank to block access to the road.

A-2.2.6 Export outsloping (EOS)

EOS is a technique comparable to IPOS, except that spoil material is moved off-site to a permanent, stable storage location. EOS is required when it is not possible to place spoil material against the cutbank, e.g., where the road prism is narrow or where there are springs along the cutbank. EOS usually requires dump trucks to endhaul the spoil material. This technique is used for both decommissioning and upgrading roads, but as the roadbed is partially or completely removed, EOS is more commonly used for decommissioning.

A-3 DETERMINING TREATMENT IMMEDIACY AND COST-EFFECTIVENESS

Identifying *treatment immediacy* is an integral part of an assessment used to prioritize sites prior to implementation. Treatment immediacy is a professional evaluation of how important it is to quickly perform erosion control or erosion prevention work. It is defined as “high,” “moderate,” or “low,” and represents the urgency of treating the site before it erodes or fails. An evaluation of treatment immediacy is based on the following criteria: (1) *erosion potential*, or whether there is a low, moderate, or high likelihood for future erosion at a site; (2) *sediment delivery*, which is an estimate of the sediment volume projected to be eroded from a site and delivered to a nearby stream; and (3) the value or sensitivity of downstream resources being protected. Generally, sites that are likely to erode or fail in a normal winter, and are expected to deliver significant quantities of sediment to a stream channel, are rated as having high treatment immediacy.

The *erosion potential* of a site is a professional evaluation of the likelihood that erosion will occur during a future storm, based on local site conditions and field observations. It is a subjective probability estimate, expressed as “low,” “moderate,” or “high,” and not an estimate of how much erosion is likely to occur. The volume of sediment projected to erode and reach stream channels is described by *sediment delivery*, which plays a significant role in determining the treatment immediacy for a site. The larger the volume of potential future sediment delivery to a stream, the more important it becomes to closely evaluate the need for treatment.

From this assessment, treatment immediacy and *cost-effectiveness* may be analyzed, along with the client’s transportation needs, to prioritize treatment sites or locations for implementation. *Cost-effectiveness* is not only a necessary consideration for environmental protection and restoration projects for which funding may be limited, but is also an accepted and well-documented tool for prioritizing potential treatment sites in an area (Weaver and Sonnevil, 1984; Weaver and Hagans, 1999). A quantitative estimate for cost-effectiveness is determined by dividing the cost of accessing and treating a site by the volume of sediment prevented from being delivered to local stream channels. The resulting value, or *sediment savings*, provides a comparison of cost-effectiveness among sites, and an average for the entire project area. For example, if the cost to develop access and treat an eroding stream crossing is projected to be \$5000, and the treatment will potentially prevent 500 yd^3 of sediment from reaching the stream channel, the predicted cost-effectiveness for that site would be \$5000/500yd^3, or \$10/yd^3.

PWA further evaluates cost-effectiveness for an entire assessment area by organizing sites into logistical groups based on similar requirements for heavy equipment and materials, and addressing these as a unit to minimize expenses. Furthermore, although sites and road segments with the lowest immediacy ratings are placed last on the list for treatment, it is sometimes possible to treat these sites once the project is underway, as opportunities to cost-effectively treat low-immediacy sites often arise when heavy equipment is already located nearby to perform maintenance or restoration at higher-immediacy sites.

References for Appendix A

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APPENDIX B

List of 166 inventoried sites showing field data and analyses, including treatment immediacy and estimates of potential sediment delivery for the site-specific problem.

Site #	Road name	Site type	Treat-ment type	Treat-ment immed-iacy	Erosion potential	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U = upgrade; D = decommission; NT = no treat. [b]H = high; HM = high-moderate; M = moderate; ML = moderate-low; L = low.								
60.1	550	Stream crossing	D	L	ML	853	398	695
61	550	Landslide	D	ML	ML	40	45	630
62	550	Ditch relief culvert	D	L	L	6	75	600
63	550	Landslide	D	ML	ML	23	0	0
64	550	Stream crossing	D	H	H	208	0	380
65	550	Ditch relief culvert	D	ML	ML	1	80	496
66	550	Landslide	D	L	L	3	140	100
67	550	Ditch relief culvert	D	M	M	14	284	210
68	550	Gully diversion	D	ML	M	33	0	200
69	550	Spring	D	L	M	4	25	100
70	550	Discharge point for road drainage	D	ML	M	4	100	222
71	550	Stream crossing	D	HM	HM	76	0	381
72	550	Stream crossing	D	M	HM	58	0	750
73	550	Stream crossing	D	ML	L	42	0	180
74	550	Stream crossing	D	ML	M	610	100	138
75	550	Stream crossing	D	ML	ML	70	1340	0
76	550	Stream crossing	D	HM	HM	222	180	0
77	550	Stream crossing	D	M	M	1210	975	0
78	550	Spring	D	ML	M	4	410	0
79	550	Stream crossing	D	M	HM	131	63	10
79.1	550 spur 1	Stream crossing	D	HM	HM	25	0	0
80	550	Stream crossing	D	M	H	193	625	35
81	550	Stream crossing	D	M	HM	547	400	0
81.5	550	Gully diversion	D	L	M	18	0	170
81.6	550	Gully diversion	D	M	ML	77	0	1000
82	550	Stream crossing	D	ML	M	153	500	0
83	550	Ditch relief culvert	D	ML	ML	44	2830	0
84	555 Spur 2	Stream crossing	D	HM	HM	433	20	0
85	550 Spur	Landslide	D	M	M	102	650	0
86	555 Spur	Stream crossing	D	HM	HM	260	145	400
87	555 Spur	Stream crossing	D	ML	M	67	0	0
88	555 Spur 1	Stream crossing	D	M	HM	1871	350	225
89	555 Spur	Stream crossing	D	H	H	225	200	30
90	555	Ditch relief culvert	D	L	L	1	0	1285

Site #	Road name	Site type	Treat-ment type	Treat-ment immed-iacy	Erosion potential	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U = upgrade; D = decommission; NT = no treat. [b]H = high; HM = high-moderate; M = moderate; ML = moderate-low; L = low.								
91	555	Stream crossing	D	H	H	1858	0	2041
92	555	Ditch relief culvert	D	L	ML	1	0	378
100	550	Landslide	NT		M	311	250	200
101	550	Landslide	NT		M	208	0	125
102	550	Landslide	NT		HM	529	0	50
103	550	Landslide	NT		HM	311	0	0
104	550	Landslide	D	L	L	252	30	0
105	550	Discharge point for road drainage	D	L	ML	2	243	110
106	550	Landslide	D	L	ML	63	0	54
107	550	Landslide	D	L	M	30		
108	550	Stream crossing	U	M	HM	558	235	415
109	550	Bank erosion	U	ML	ML	67	0	0
110	550	Ditch relief culvert	U	ML	M	8	0	400
111	550	Stream crossing	U	M	H	368	20	0
112	550	Ditch relief culvert	U	M	M	7	232	432
113	550	Ditch relief culvert	U	ML	ML	13	0	150
114	550	Discharge point for road drainage	U	L	ML	12	0	173
115	550	Ditch relief culvert	U	ML	M	7	333	0
116	561	Stream crossing	U	HM	M	779	0	653
117	561	Swale	U	L		3	0	200
118	561	Stream crossing	U	M	M	120	0	25
119	561	Stream crossing	U	M	M	326	100	264
120	555	Stream crossing	D	HM	HM	211	1150	20
121	555	Spring	D	ML	ML	8	20	0
122	555	Bank erosion	D	M	HM	93	850	200
123	555	Stream crossing	D	HM	HM	263	700	0
124	555	Stream crossing	D	ML	M	591	0	725
125	555	Landslide	D	L	ML	36	0	0
126	555	Stream crossing	D	M	M	365	375	375
127	555	Stream crossing	D	M	HM	408	0	1450
130	730	Ditch relief culvert	U	ML	ML	1	0	2000
131	730	Stream crossing	U	HM	M	121	0	2764
132	730	Ditch relief culvert	U	L	L	1	0	160
133	730	Stream crossing	U	H	M	193	0	381
134	730	Stream crossing	U	H	H	45	0	1255

Site #	Road name	Site type	Treat-ment type	Treat-ment immed-iacy	Erosion potential	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U = upgrade; D = decommission; NT = no treat. [b]H = high; HM = high-moderate; M = moderate; ML = moderate-low; L = low.								
135	730	Stream crossing	U	ML	ML	135	0	20
136	730	Spring	U	L	L	1	0	485
137	730	Stream crossing	U	L	M	85	0	508
138	730	Stream crossing	U	M	M	80	0	651
139	730	Stream crossing	U	H	ML	4	0	660
139.8	400	Bank erosion	U	HM	HM	8	0	0
139.9	400	Bank erosion	U	HM	HM	8	0	0
140	400	Stream crossing	U	L	ML	112	310	1500
141	400	Spring	U	L	L	0	69	93
142	400	Stream crossing	U	L	L	54	1073	232
143	400	Stream crossing	D	H	H	72	0	1189
144	400	Spring	D	L	L	12	0	234
145	400	Spring	D	ML	L	12	252	479
146	400	Spring	D	L	L	12	0	71
147	400	Ditch relief culvert	D	L	L	12	196	472
147.5	400	Bank erosion	D	M	M	133	0	0
148	400	Ditch relief culvert	D	L	L	15	113	122
149	400	Stream crossing	D	ML	L	31	329	0
150	400	Stream crossing	D	H	ML	40	0	30
151	400	Stream crossing	D	ML	ML	173	0	23
151.5	400	Landslide	D	ML	ML	233	0	0
152	400	Ditch relief culvert	D	L	L	0	264	500
153	400	Stream crossing	D	L	L	13	73	0
154	400	Stream crossing	D	L	M	38	75	0
155	400	Stream crossing	D	ML	HM	69	30	0
156	400	Ditch relief culvert	D	L	L	2	300	120
157	400	Ditch relief culvert	D	L	L	0	222	190
158	400	Spring	D	L	ML	28	0	58
159	400	Ditch relief culvert	D	L	L	40	70	90
160	400	Stream crossing	D	L	ML	117	0	120
161	400	Ditch relief culvert	D	L	L	0	0	322
162	400	Bank erosion	D	M	HM	187	254	30
163	400	Ditch relief culvert	D	L	L	0	50	0
164	400	Stream crossing	D	L	M	387	650	0
165	400	Stream crossing	D	L	L	147	0	65
166	400	Ditch relief culvert	D	L	L	0	440	260

Site #	Road name	Site type	Treat-ment type	Treat-ment immed-iacy	Erosion potential	Estimated site-specific sediment delivery (yd³)	Left ditch/road length (ft)	Right ditch/road length (ft)
aU = upgrade; D = decommission; NT = no treat. bH = high; HM = high-moderate; M = moderate; ML = moderate-low; L = low.								
167	400	Ditch relief culvert	D	L	L	0	303	0
168	400	Landslide	D	M	M	111	0	0
169	400	Landslide	D	L	HM	30	0	0
170	400	Stream crossing	D	L	ML	144	0	90
171	400	Bank erosion	D	L	M	321	0	0
172	400	Ditch relief culvert	D	L	L	1	305	700
173	400	Stream crossing	D	L	ML	540	304	115
174	400	Swale	D	L	L	2	198	0
174.5	400	Landslide	D	ML	ML	61	0	0
175	400	Stream crossing	D	M	ML	385	0	168
176	400	Ditch relief culvert	D	L	ML	0	656	412
178	400	Ditch relief culvert	U	L	L	1	433	364
179	400	Stream crossing	U	L	ML	52	45	0
180	400	Ditch relief culvert	U	L	ML	0	400	100
181	400	Ditch relief culvert	U	L	ML	0	362	0
182	400	Ditch relief culvert	U	L	L	0	438	83
183	400	Ditch relief culvert	U	L	L	0	691	0
184	400	Bank erosion	U	L	L	460	0	0
185	400	Stream crossing	U	L	ML	128	0	208
186	400	Landslide	U	ML	M	280		
187	400	Ditch relief culvert	U	L	L	2	328	511
188	400	Stream crossing	U	L	L	0	688	0
190	400	Stream crossing	D	M	HM	14	180	13
191	400	Stream crossing	D	L	HM	15	366	0
192	400	Ditch relief culvert	D	L	ML	2	0	100
193	400	Ditch relief culvert	D	L	L	4	208	175
194	400	Stream crossing	D	H	HM	74	108	400
195	400	Stream crossing	D	ML	M	62	98	0
196	400	Stream crossing	D	L	L	48	660	166
197	400	Stream crossing	D	L	L	27	420	0
198	400	Ditch relief culvert	D	L	L	0	120	170
199	400	Ditch relief culvert	D	L	L	0	640	90
200	400	Stream crossing	D	L	L	6	0	150
201	400	Stream crossing	D	L	HM	35	126	60
202	400	Ditch relief culvert	D	L	L	0	395	140
203	440	Stream crossing	U	ML	ML	67	1027	0

Site #	Road name	Site type	Treat-ment type	Treat-ment immed-iacy	Erosion potential	Estimated site-specific sediment delivery (yd^3)	Left ditch/road length (ft)	Right ditch/road length (ft)
[a]U = upgrade; D = decommission; NT = no treat. [b]H = high; HM = high-moderate; M = moderate; ML = moderate-low; L = low.								
204	440	Stream crossing	U	L	L	128	85	0
205	440	Stream crossing	U	L	L	29	582	0
206	440	Spring	U	L	L	9	41	0
207	440	Stream crossing	U	L	ML	163	587	0
208	440	Ditch relief culvert	U	L	ML	0	390	0
209	440	Ditch relief culvert	U	L	ML	2	388	0
210	440	Bank erosion	U	L	M	188	0	0
211	440	Stream crossing	U	L	ML	6	220	0
212	440	Bank erosion	U	ML	HM	48	0	0
213	440	Ditch relief culvert	U	L	L	11	380	0
214	440	Stream crossing	U	ML	L	8	100	0
215	440	Ditch relief culvert	U	L	M	37	175	0
216	440	Stream crossing	U	HM	ML	11	0	30
217	440	Stream crossing	U	HM	ML	11	154	0
218	440	Bank erosion	U	ML	ML	37	0	0
219	440	Ditch relief culvert	U	L	ML	1	235	0
220	440	Ditch relief culvert	U	ML	ML	0	187	0
221	440	Stream crossing	U	HM	ML	12	190	0
222	440	Stream crossing	U	M	HM	538	0	219
222.1	440	Bank erosion	U	HM	HM	45	0	0
223	440	Stream crossing	U	H	H	15	0	288
224	440	Stream crossing	U	ML	M	441	262	0
224.1	440	Bank erosion	U	HM	HM	80	0	0
225	440	Ditch relief culvert	U	L	M	28	536	203
226	440	Ditch relief culvert	U	L	L	0	569	1400

APPENDIX C

Typical drawings (schematic diagrams) of recommended erosion control and erosion prevention treatments

No.	Drawing title
1	Typical problems and applied treatments for a non-fish bearing upgraded stream crossing
2	Typical design of a non-fish bearing culverted stream crossing
3	Typical design of a single-post culvert inlet trash rack
4	Typical design for armoring fillslopes
5	General armored fill dimensions
6	Typical armored fill crossing installation
7	Ten steps for constructing a typical armored fill crossing
8	Typical ditch relief culvert installation
9	Typical designs for using road shape to control road runoff (using insloping, outsloping, and crowning)
10	Typical methods for dispersing road surface runoff with waterbars, cross-road drains, and rolling dips
11	Typical road surface drainage by rolling dips
12	Typical sidecast or excavation methods for removing outboard berms on a maintained road
13	Typical excavation of unstable fillslope on an upgraded road
14	Typical problems and applied treatments for a decommissioned stream crossing
15	Typical design for road decommissioning treatments employing export and in-place outsloping techniques
16	Typical excavation of unstable fillslope on a decommissioned road

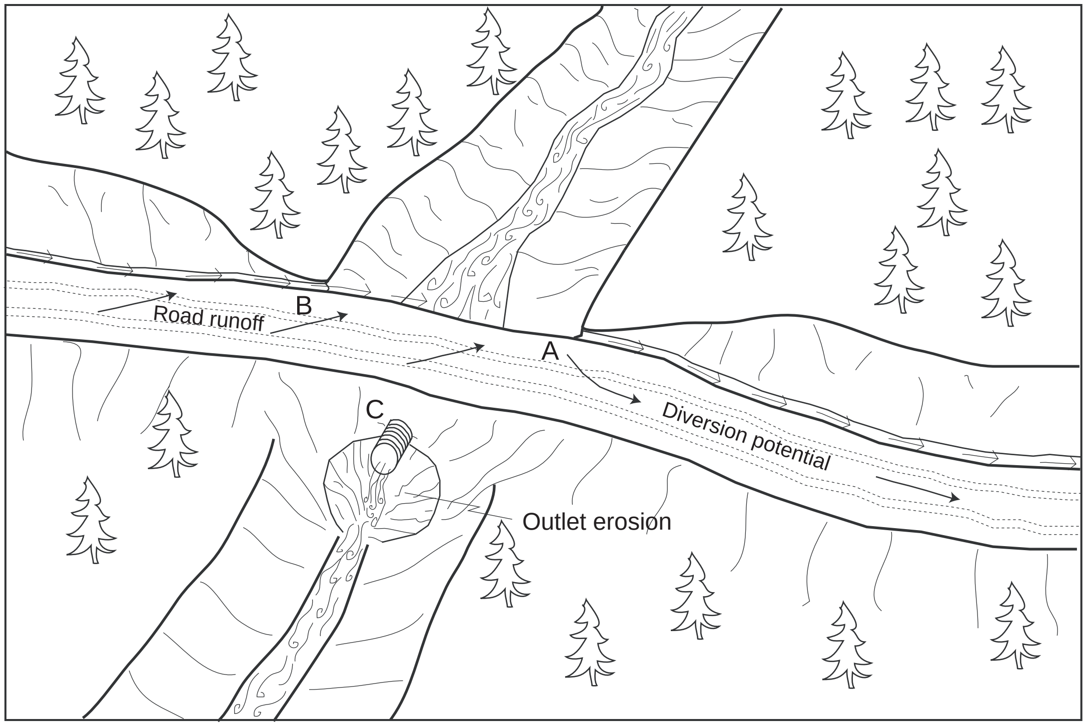
Typical Problems and Applied Treatments for a Non-fish Bearing Upgraded Stream Crossing

Problem condition (before)

A - Diversion potential

B - Road surface and ditch drain to stream

C - Undersized culvert high in fill with outlet erosion

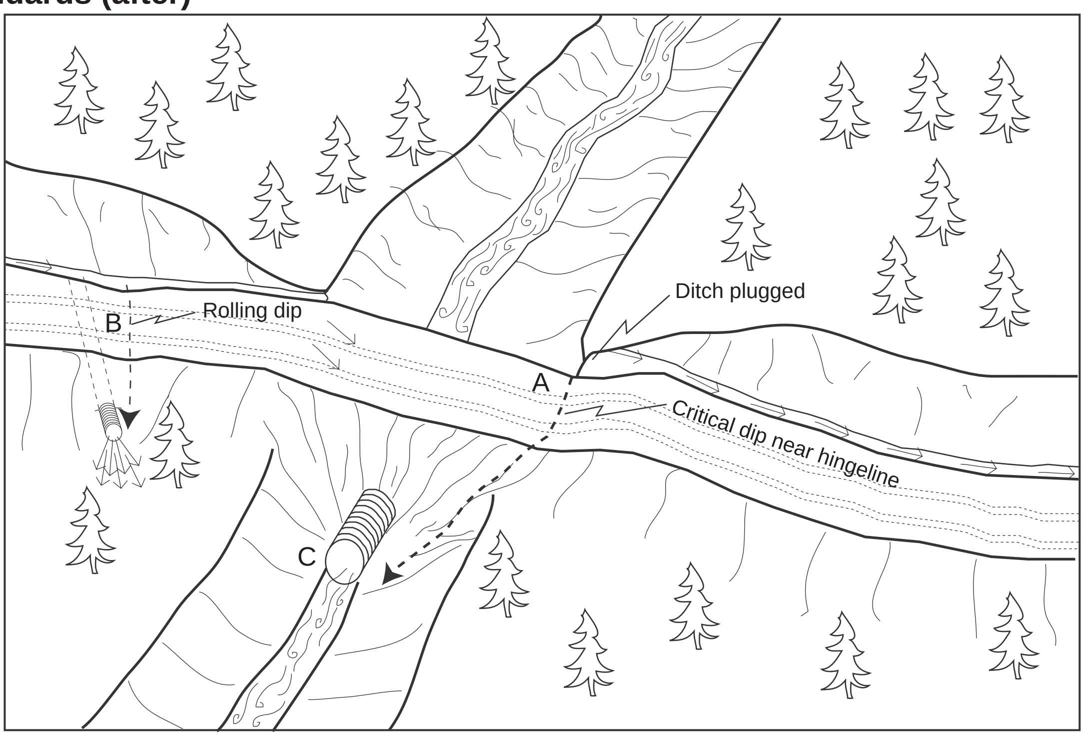


Treatment standards (after)

A - No diversion potential with critical dip installed near hingeline

B - Road surface and ditch disconnected from stream by rolling dip and ditch relief culvert

C - 100-year culvert set at base of fill



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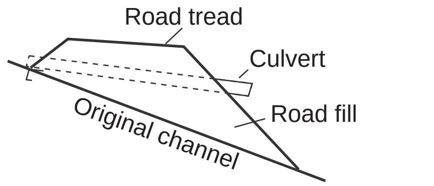
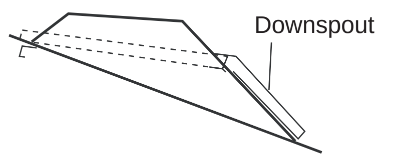
Typical Design of a Non-fish Bearing Culverted Stream Crossing

Existing



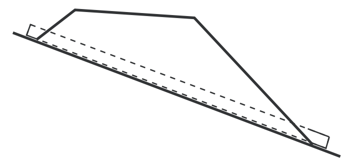
1. Culvert not placed at channel grade.
2. culvert does not extend past base of fill.

Upgraded



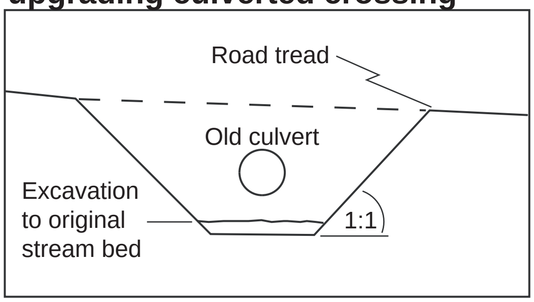
1. Culvert not placed at channel grade.
2. Downspout added to extend outlet past road fill.

Upgraded (preferred)

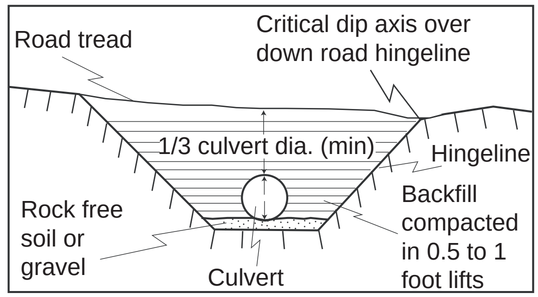


1. Culvert placed at channel grade.
2. Culvert inlet and outlet rest on, or partially in, the originial streambed.

Excavation in preparation for upgrading culverted crossing



Upgraded stream crossing culvert installation



Note:
Road upgrading tasks typically include upgrading stream crossings by installing larger culverts and inlet protection (trash barriers) to prevent plugging. Culvert sizing for the 100-year peak storm flow should be determined by both field observation and calulations using a procedure such as the Rational Formula.

Stream crossing culvert Installation

1. Culverts shall be aligned with natural stream channels to ensure proper function, and prevent bank erosion and plugging by debris.
2. Culverts shall be placed at the base of the fill and the grade of the original streambed, or downspouted past the base of the fill.
3. Culverts shall be set slightly below the original stream grade so that the water drops several inches as it enters the pipe.
5. To allow for sagging after burial, a camber shall be between 1.5 to 3 incher per 10 feet culvert pipe length.
6. Backfill material shall be free of rocks, limbs or other debris that could dent or puncture the pipe or allow water to seep around pipe.
7. First one end then the other end of the culvert shall be covered and secured.;The center is covered last.
8. Backfill material shall be tamped and compacted throughout the entire process:
   - Base and side wall material will be compacted before the pipe is placed in its bed.
   - Backfill compacting will be done in 0.5 - 1 foot lifts until 1/3 of the diameter of the culvert has been covered. A gas powered tamper can be used for this work.
9. Inlets and outlets shall be armored with rock or mulched and seeded with grass as needed.
10. Trash protectors shall be installed just upstream from the culvert where there is a hazard of floating debris plugging the culvert.
11. Layers of fill will be pushed over the crossing until the final designed road grade is achieved, at a minimum of 1/3 to 1/2 the culvert diameter.

Erosion control measures for culvert replacement

Both mechanical and vegetative measures will be employed to minimize accelerated erosion from stream crossing and ditch relief culvert upgrading. Erosion control measures implemented will be evaluated on a site by site basis. Erosion control measures include but are not limited to:

1. Minimizing soil exposure by limiting excavation areas and heavy equipment distrubance.
2. Installing filter windrows of slash at the base of the road fill to minimize the movement of eroded soil to downslope areas and stream channels.
3. Retaining rooted trees and shrubs at the base of the fill as “anchor” for the fill and filter windrows.
4. Bare slopes created by construction operations will be protected until vegetation can stabilize the surface. Surface erosion on exposed cuts and fills will be minimized by mulching, seeding, planting, compacting, armoring, and/or benching prior to the first rains.
5. Excess or unusable soil will be stored in long term spoil disposal locations that are not limited by factors such as excessive moisture, steep slopes greater than 10%, archeology potential, or proximity to a watercourse.
6. On running streams, water will be pumped or diverted past the crossing and into the downstream channel during the construction process.
7. Straw bales and/or silt fencing will be employed where necessary to control runoff within the construction zone.

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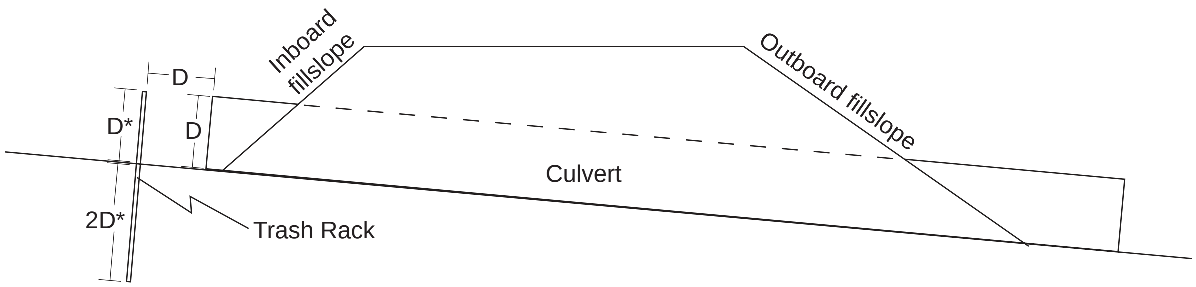
Typical Design of a Single-post Culvert Inlet Trash Rack

Cross section view



D - Culvert diameter

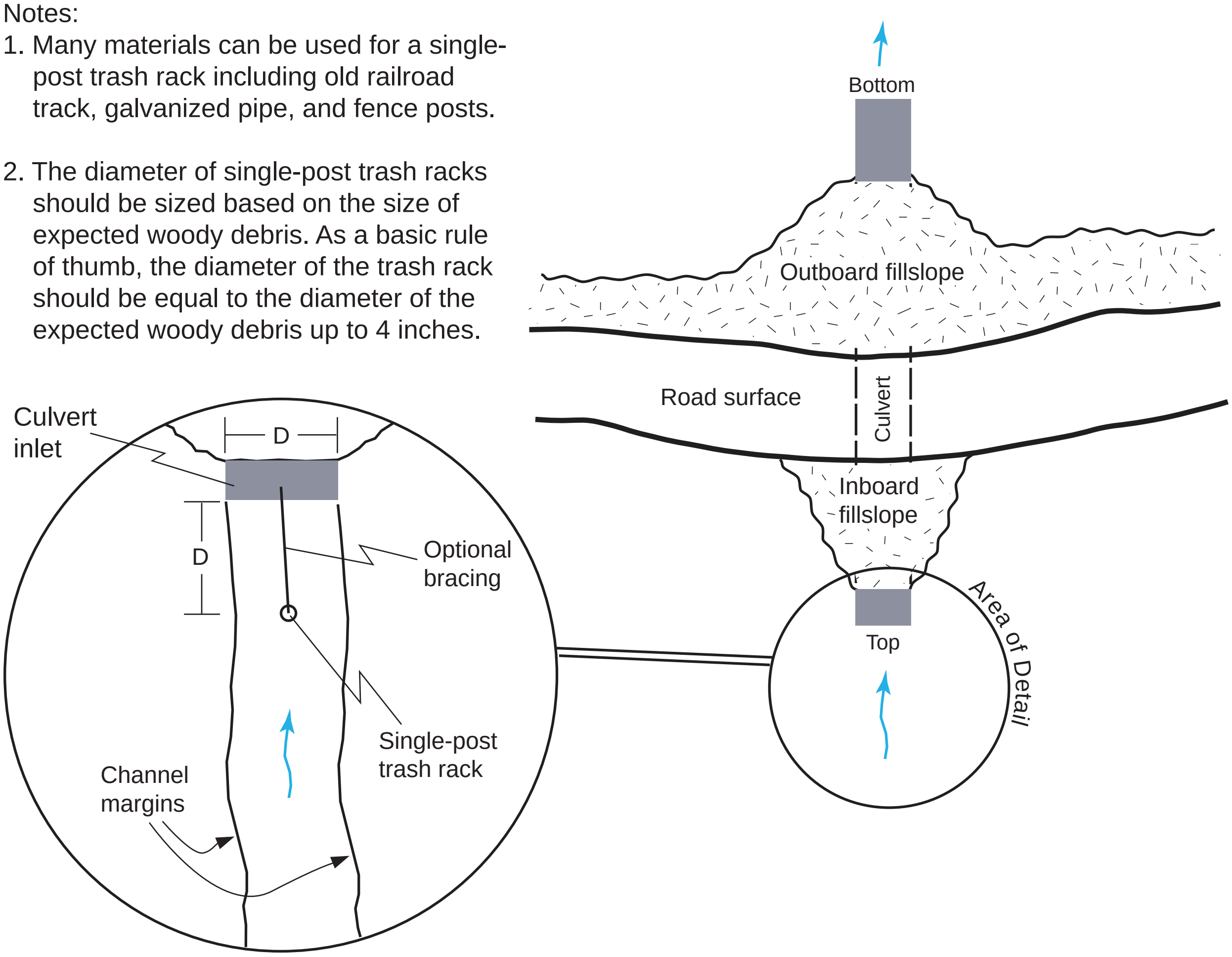
D* - If the culvert is designed for the 100-year peak storm flow, the trash rack height above the streambed should equal D.
If the culvert is undersized, then the trash rack needs to be extended vertically above the streambed to match or exceed the expected headwall height.

Plan view

Notes:

1. Many materials can be used for a single-post trash rack including old railroad track, galvanized pipe, and fence posts.

2. The diameter of single-post trash racks should be sized based on the size of expected woody debris. As a basic rule of thumb, the diameter of the trash rack should be equal to the diameter of the expected woody debris up to 4 inches.



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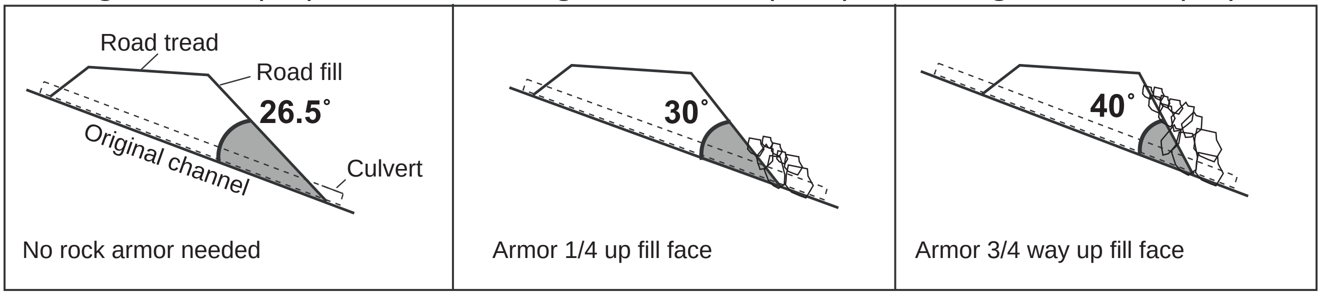
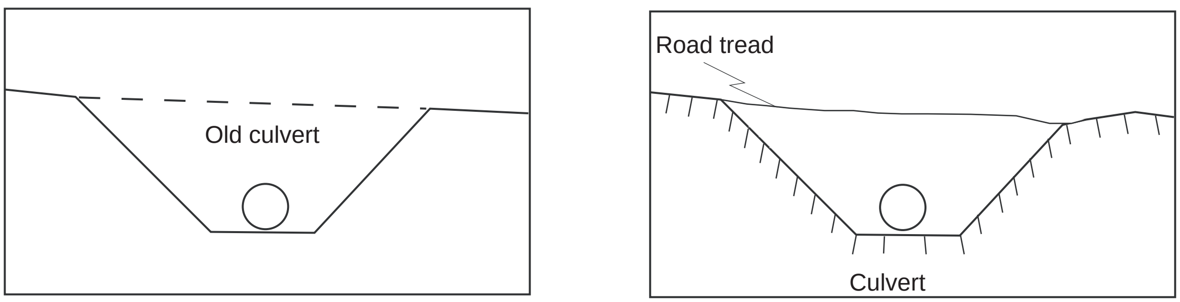
Typical Design of Stream Crossing Fill Armor

Fill angles ≤26.5˚ (2:1) **Fill angles 26.5˚ - 35˚ (1.5:1)** **Fill angles 35˚ - 45˚ (1:1)**



Fill angles 26.5˚ - 35˚ (1.5:1) **Fill angles 35˚ - 45˚ (1:1)**



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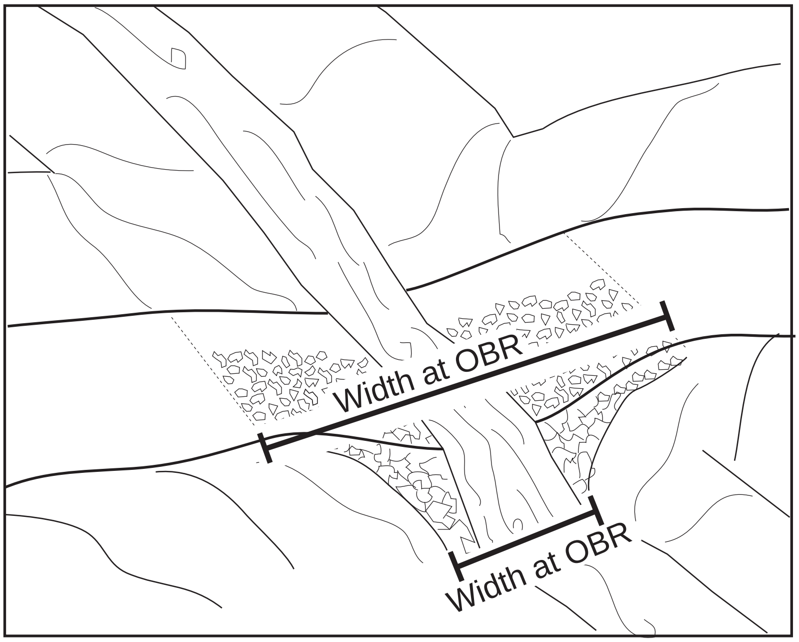
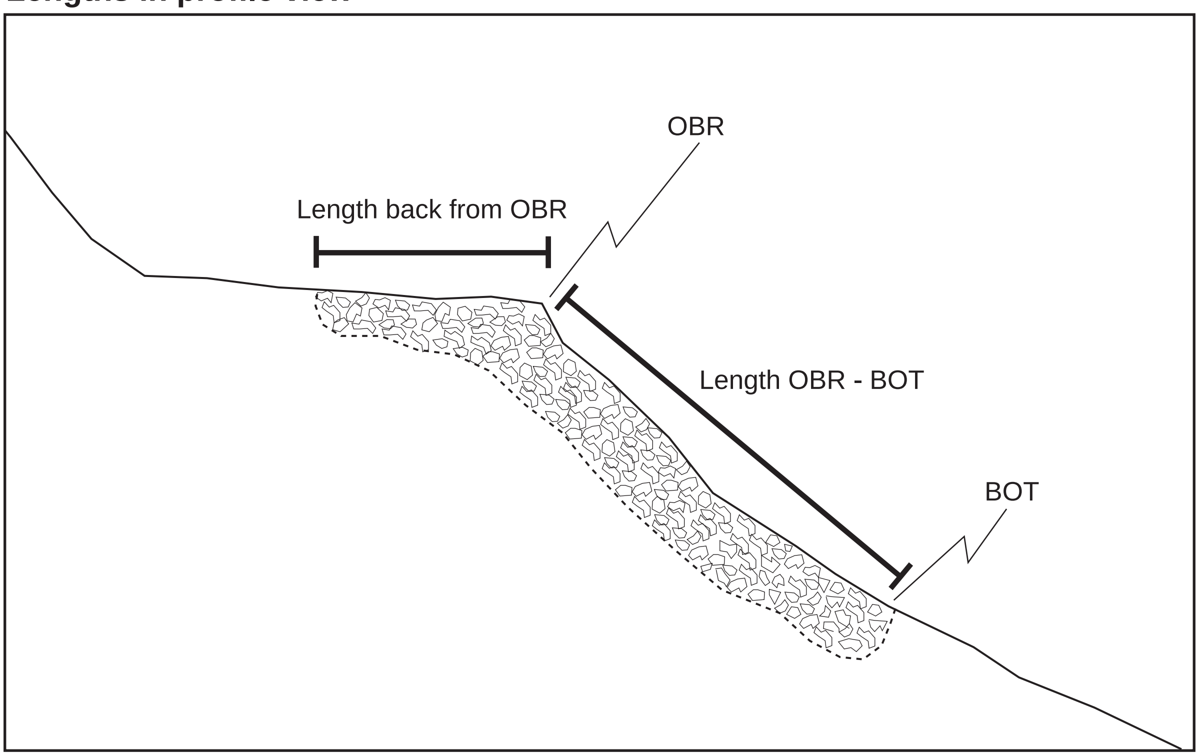
Typical Dimensions Refered to for Armored Fill Crossings

Widths in oblique view



OBR - Outboard edge of road

Lengths in profile view



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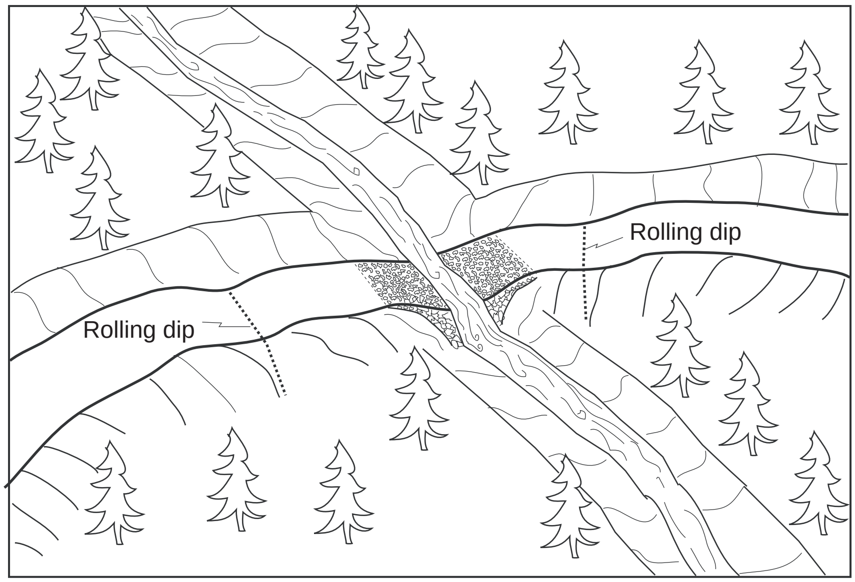
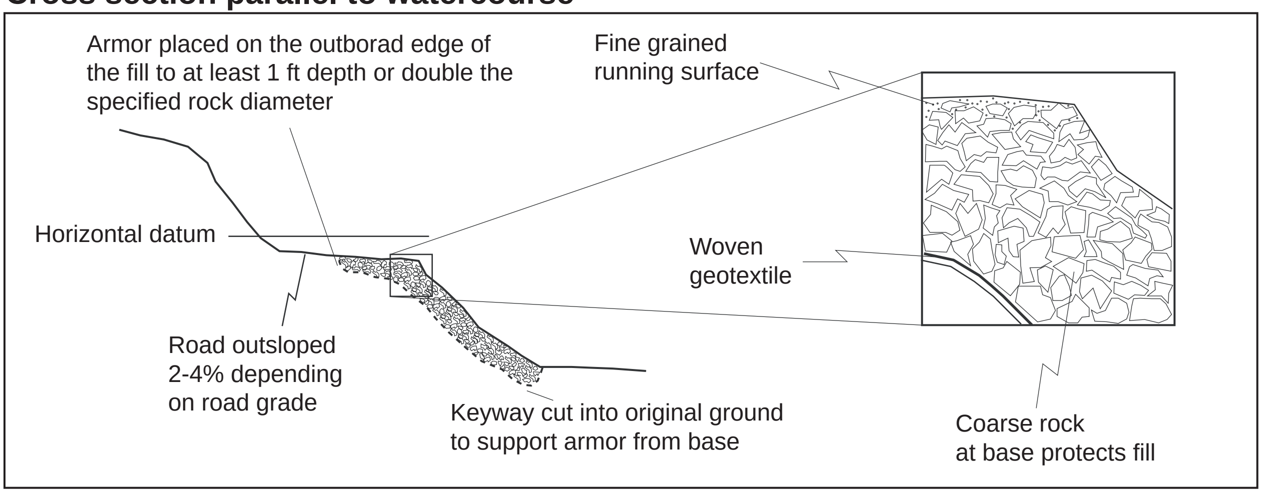
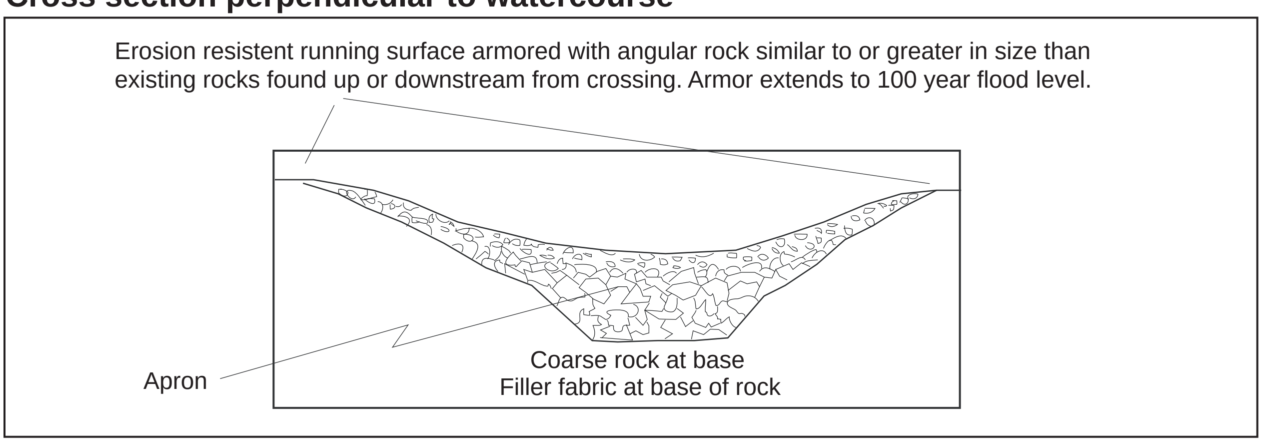
Typical Armored Fill Crossing Installation



Cross section parallel to watercourse



Cross section perpendicular to watercourse



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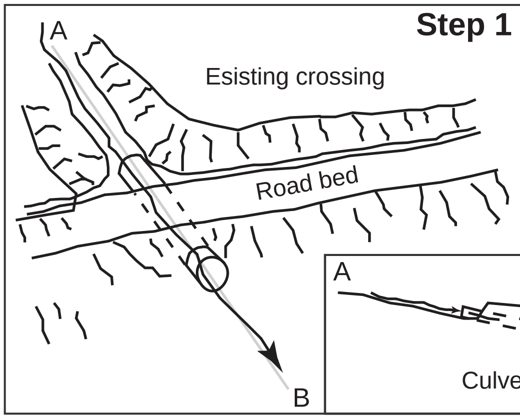
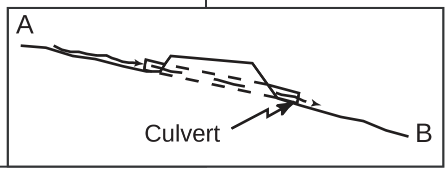
Ten Steps for Constructing a Typical Armored Fill Stream Crossing

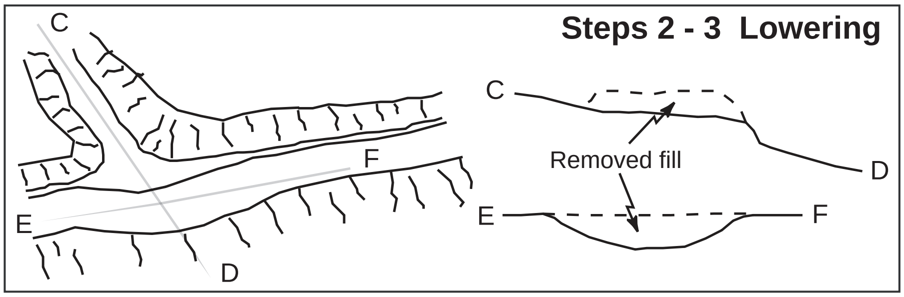




1. The two most important points are:

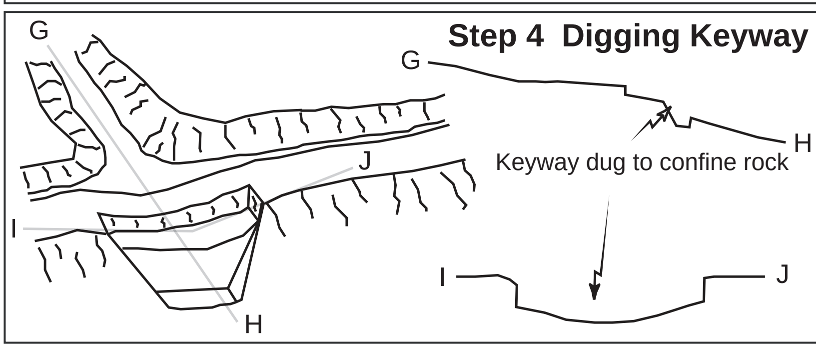
A) **The rock must be placed in a "U" shape across the channel to confine flow within the armored area.** (Flow around the rock armor will gully the remaining fill. Proper shape of surrounding road fill and good rock placement will reduce the likelihood of crossing failure).

B) **The largest rocks must be used to buttress the rest of the armor in two locations:** (i) The base of the armored fill where the fill meets natural channel. (This will butress the armor placed on the outboard fill face and reduce the likelihood of it washing downslope). (ii) The break in slope from the road tread to the outer fill face. (This will butress the fill placed on the outer road tread and will determine the "base level" of the creek as it crosses the road surface).



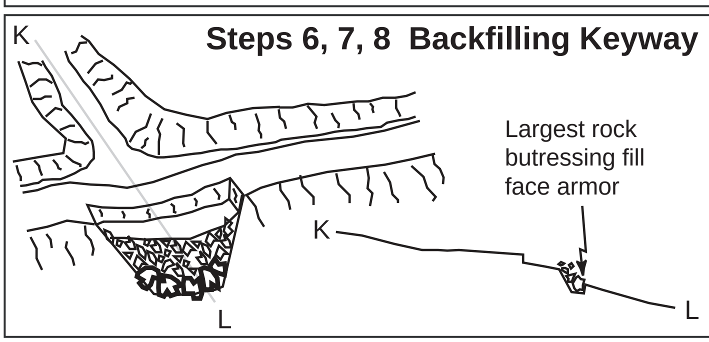
2. Remove any existing drainage structures including culverts and Humboldt logs.

3. Construct a dip centered at the crossing that is large enough to accomodate the 100-year peak storm flow and prevent diversion (C-D, E-F).



4. Dig a keyway (to place rock in) that extends from the outer 1/3 of the road tread down the outboard road fill to the point where outbaord fill meets natural channel (up to 3 feet into the channel bed depending on site specifics) (G-H, I-J).

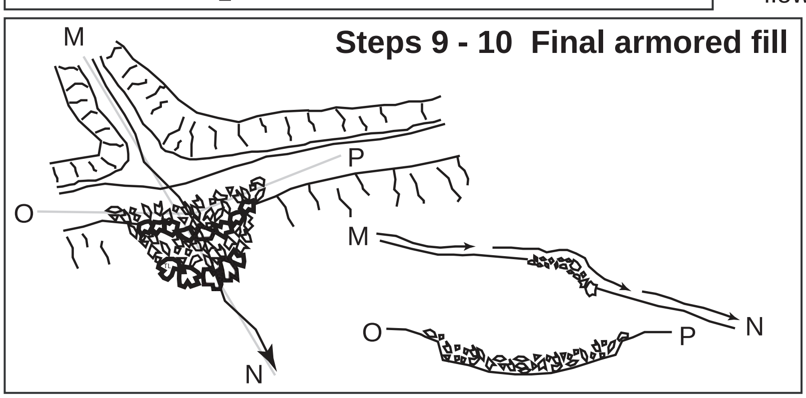
5. Install geofabric (optional) within keyway to support rock in wet areas and to prevent winnowing of the crossing at low flows.



6. Put aside the largest rock armoring to create 2 buttresses in the next step.

7. Create a buttress using the largest rock (as described in the site treatments specifications) at the base of fill. (This should have a "U" shape to it and will define the outlet of the armored fill.)

8. Backfill the fill face with remaining rock armor making sure the final armored area has "U" shape that will accomodate the largest expected flow (K-L).



9. Install a second buttress at the break in slope between the outboard road and the outboard fill face. (This should define the base level of the stream and determine how deep the stream will backfill after construction). (M-N)

10. Back fill the rest of the keyway with the unsorted rock armor making sure the final armored area has a "U" shape that will accommodate the largest expected flow (O-P).

Typical Drawing #7

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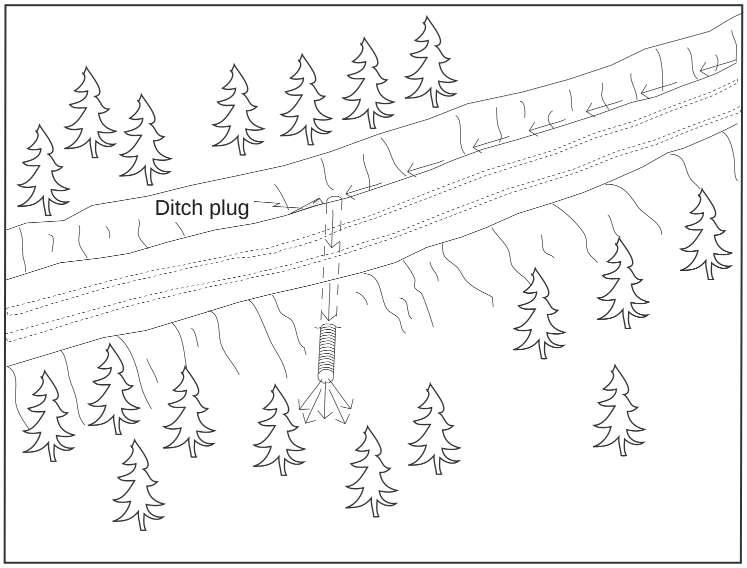
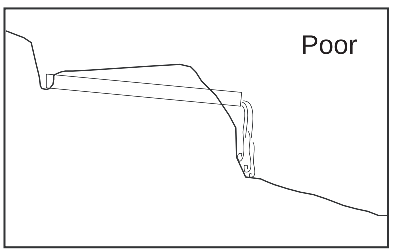
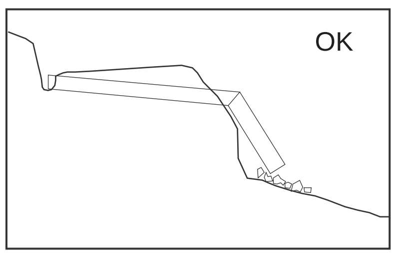
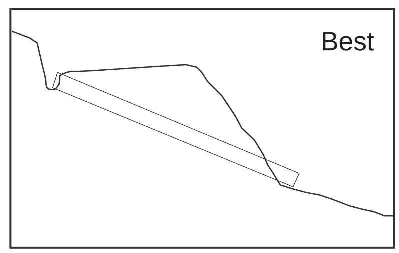
Typical Ditch Relief Culvert Installation









Ditch relief culvert installation

1) The same basic steps followed for stream crossing installation shall be employed.
2) Culverts shall be installed at a 30 degree angle to the ditch to lessen the chance of inlet erosion and plugging.
3) Culverts shall be seated on the natural slope or at a minimum depth of 5 feet at the outside edge of the road, whichever is less.
4) At a minimum, culverts shall be installed at a slope of 2 to 4 percent steeper than the approaching ditch grade, or at least 5 inches every 10 feet.
5) Backfill shall be compacted from the bed to a depth of 1 foot or 1/3 of the culvert diameter, which ever is greater, over the top of the culvert.
6) Culvert outlets shall extend beyond the base of the road fill (or a flume downspout will be used). Culverts will be seated on the natural slope or at a depth of 5 feet at the outside edge of the road, whichever is less.

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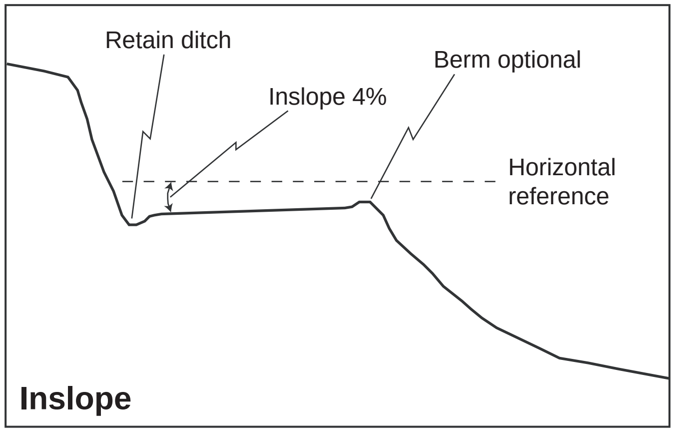
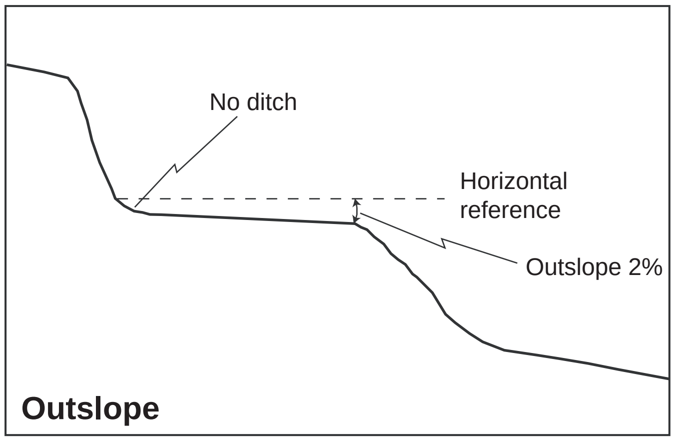
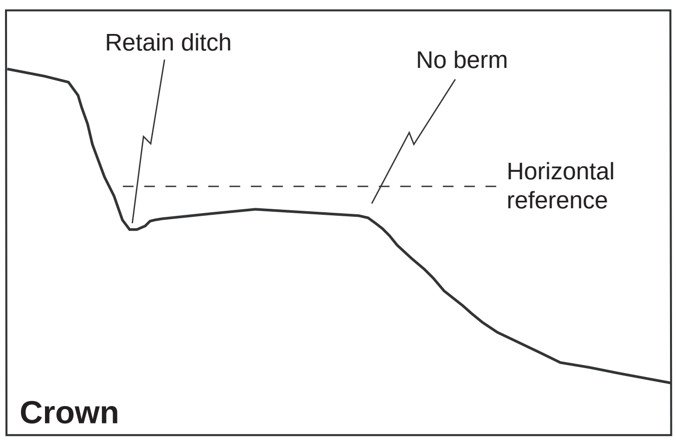
Typical Designs for Using Road Shape to Control Road Runoff







Outsloping Pitch for Roads Up to 8% Grade		
Road grade	**Unsurfaced roads**	**Surfaced roads**
4% or less	3/8" per foot	1/2" per foot
5%	1/2" per foot	5/8" per foot
6%	5/8" per foot	3/4" per foot
7%	3/4" per foot	7/8" per foot
8% or more	1" per foot	1 1/4" per foot

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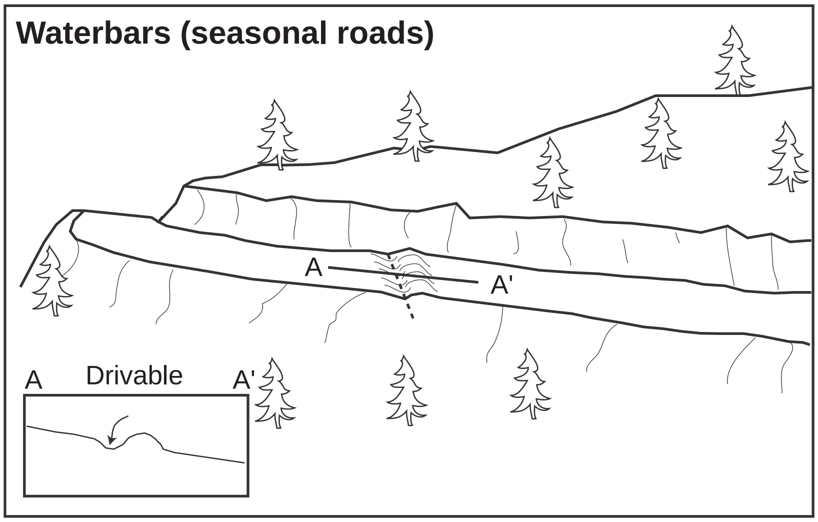
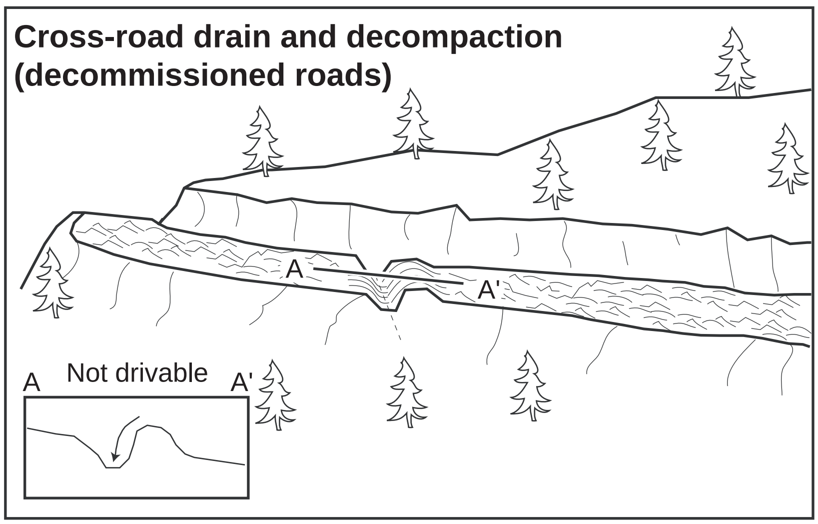
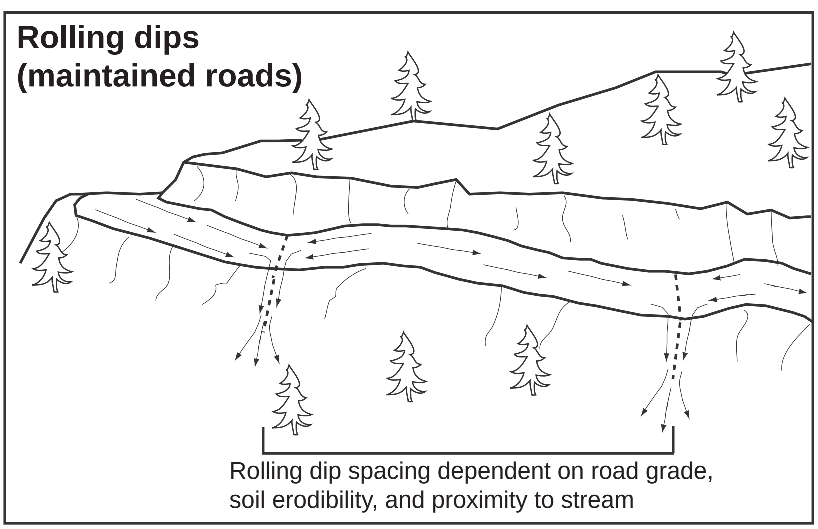
Typical Methods for Dispersing Road Surface Runoff with Waterbars, Cross-road Drains, and Rolling Dips







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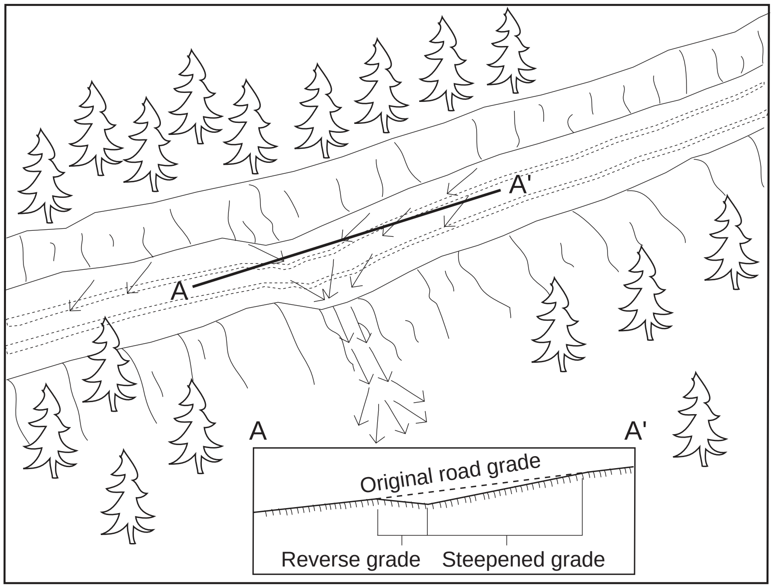
Typical Road Surface Drainage by Rolling Dips



Rolling dip installation:

1. Rolling dips will be installed in the roadbed as needed to drain the road surface.
2. Rolling dips will be sloped either into the ditch or to the outside of the road edge as required to properly drain the road.
3. Rolling dips are usually built at 30 to 45 degree angles to the road alignment with cross road grade of at least 1% greater than the grade of the road.
4. Excavation for the dips will be done with a medium-size bulldozer or similar equipment.
5. Excavation of the dips will begin 50 to 100 feet up road from where the axis of the dip is planned as per guidelines established in the rolling dip dimensions table.
6. Material will be progressively excavated from the roadbed, steepening the grade unitl the axis is reached.
7. The depth of the dip will be determined by the grade of the road (see table below).
8. On the down road side of the rolling dip axis, a grade change will be installed to prevent the runoff from continuing down the road (see figure above).
9. The rise in the reverse grade will be carried for about 10 to 20 feet and then return to the original slope.
10. The transition from axis to bottom, through rising grade to falling grade, will be in a road distance of at least 15 to 30 feet.

Table of rolling dip dimensions by road grade

Road grade %	**Upslope approach distance** (from up road start to trough) ft	**Reverse grade distance** (from trough to crest) ft	**Depth at trough outlet** (below average road grade) ft	**Depth at trough inlet** (below average road grade) ft
<6	55	15 - 20	0.9	0.3
8	65	15 - 20	1.0	0.2
10	75	15 - 20	1.1	0.01
12	85	20 - 25	1.2	0.01
>12	100	20 - 25	1.3	0.01

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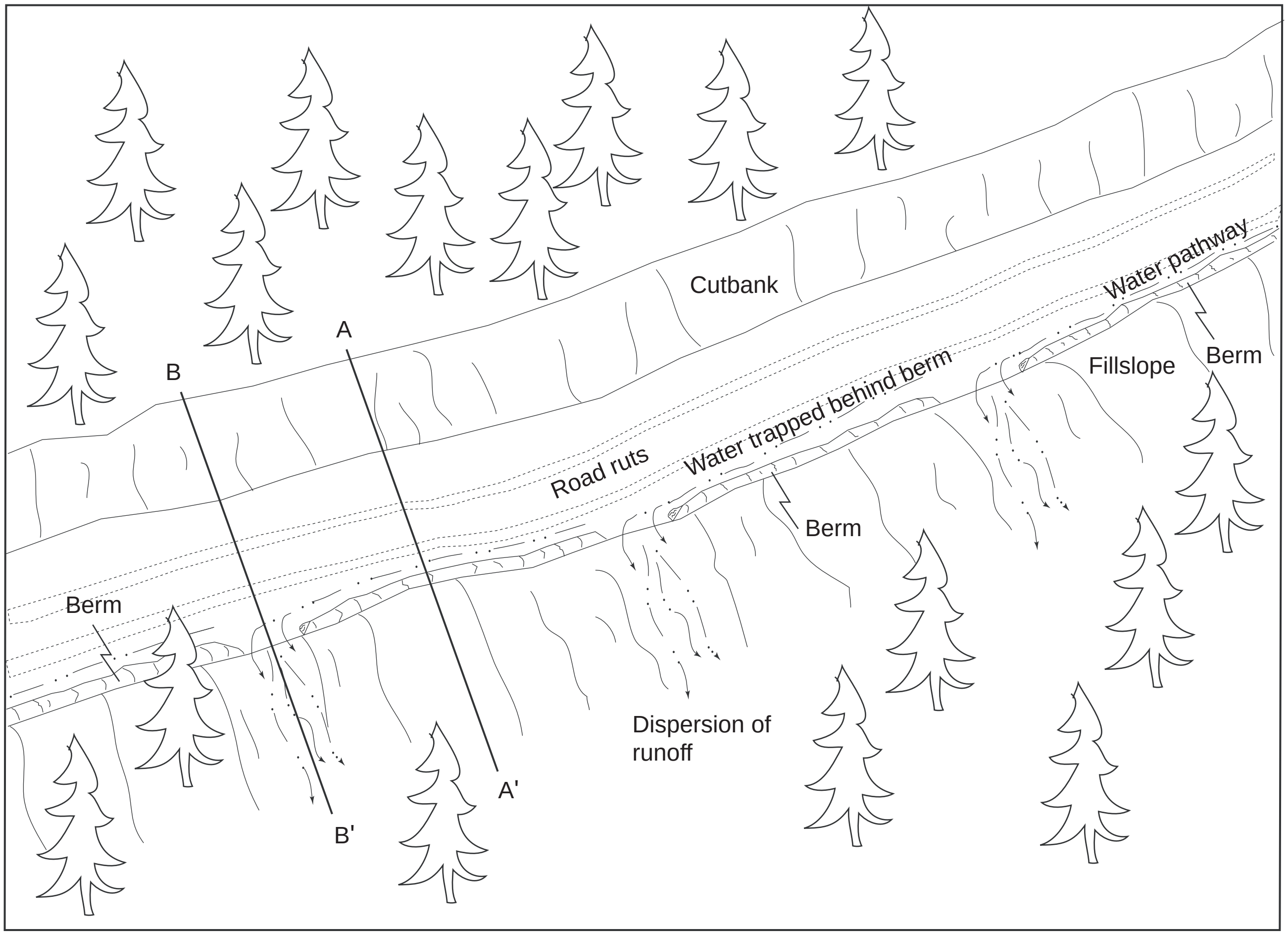
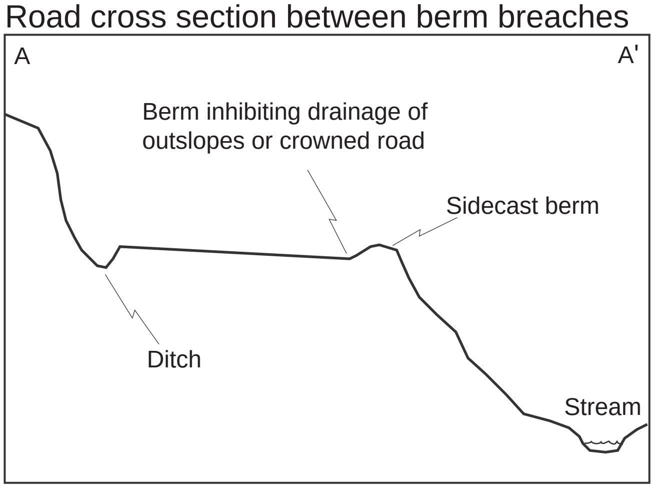
Typical Sidecast or Excavation Methods for Removing Outboard Berms on a Maintained Road

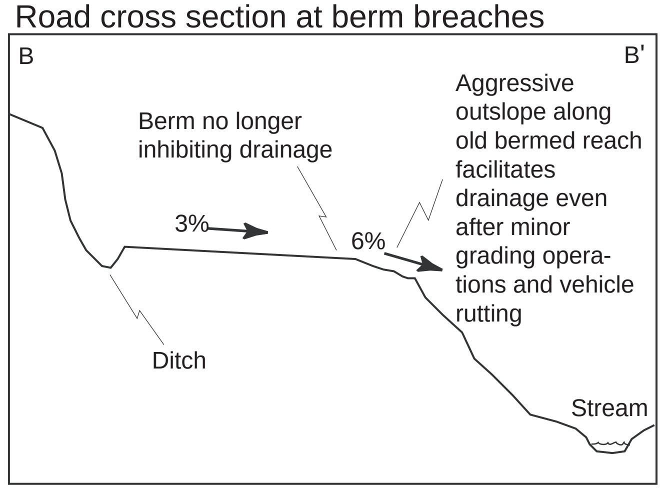
1. On gentle road segments berms can be removed continuously (see B-B').
2. On steep road segments, where safety is a concern, the berm can be frequently breached (see A-A' & B-B') Berm breaches should be spaced every 30 to 100 feet to provide adequate drainage of the road system while maintaining a semi-continuous berm for vehicle safety.



Road cross section between berm breaches



Road cross section at berm breaches



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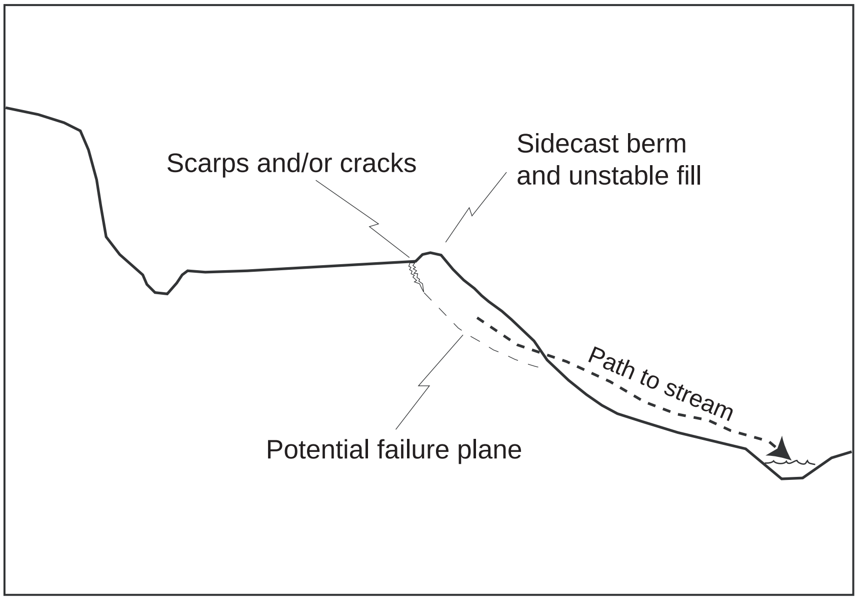
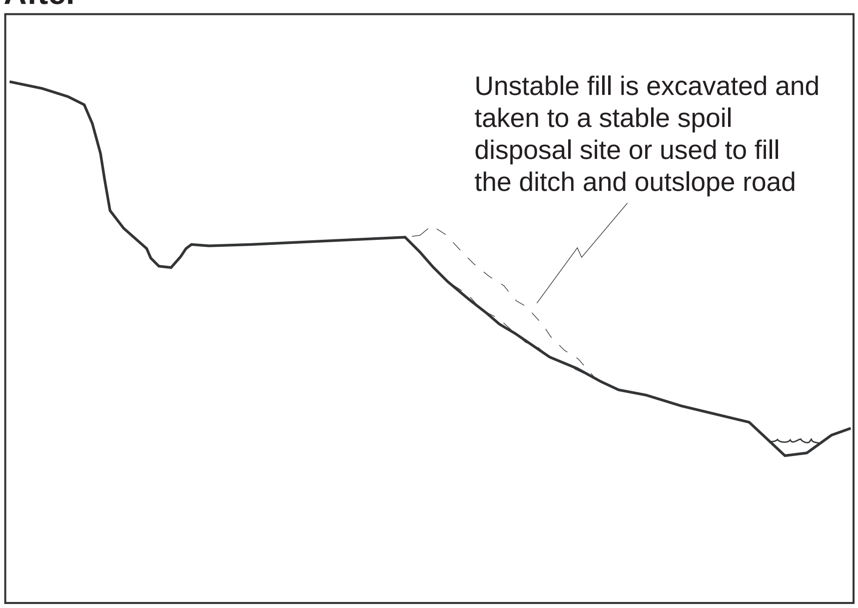
Typical Excavation of Unstable Fillslope on an Upgraded Road

Before



After



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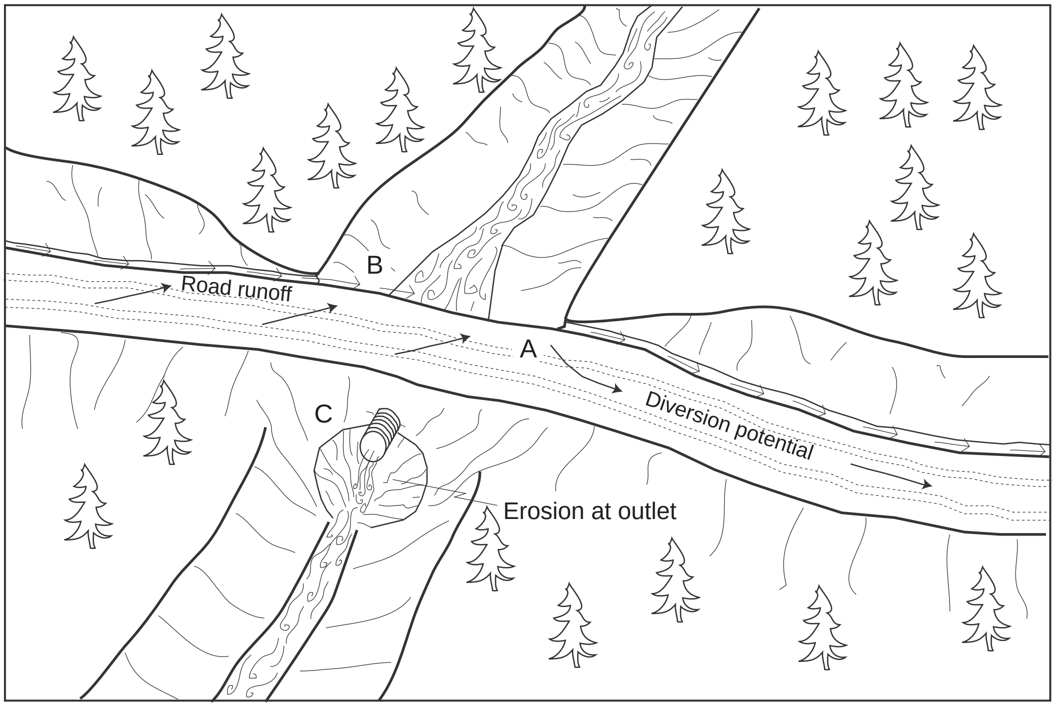
Typical Problems and Applied Treatments for a Decommissioned Stream Crossing

Problem condition (before)

A - Diversion potential

B - Road surface and ditch drain to stream

C - Undersized culvert high in fill with outlet erosion

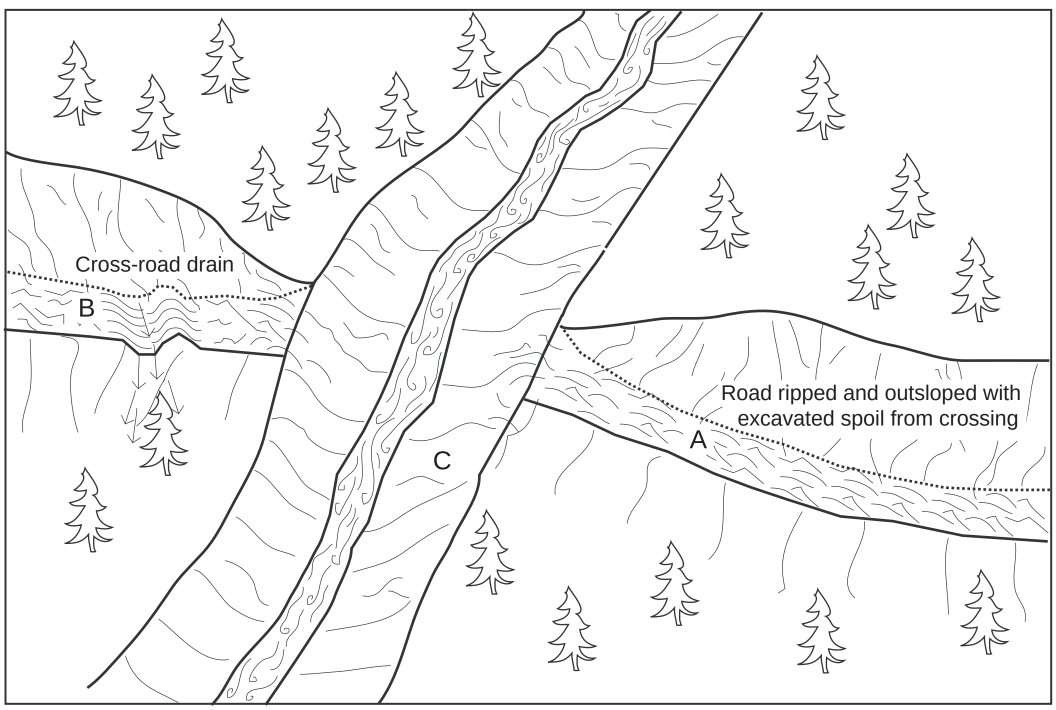


Treatment standards (after)

A - Diversion prevented by road surface ripping and outsloping using excavated spoils

B - Road surface and ditch disconnected from stream by road surface decompaction and cross-road drains

C - Stream crossing fill completely excavated



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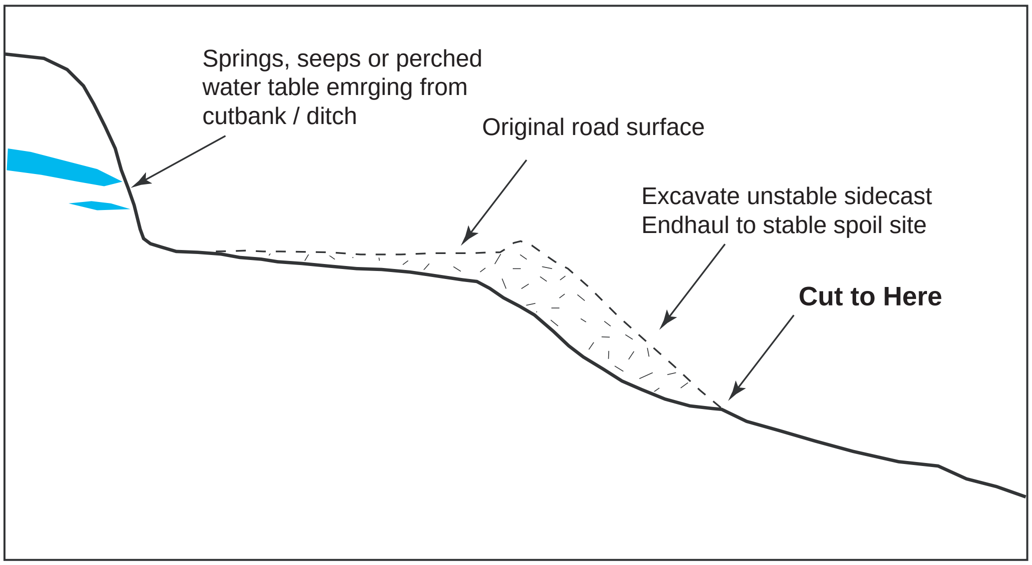
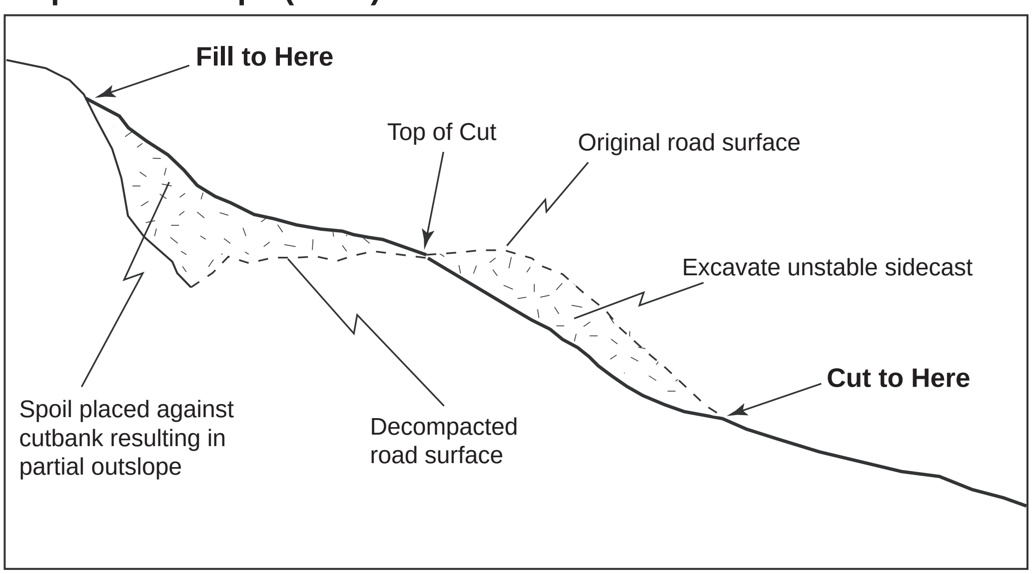
Typical Design for Road Decommisioning Treatments Employing Export and In-Place Outsloping Techniques

Export outslope (EPOS)



In-place outslope (IPOS)



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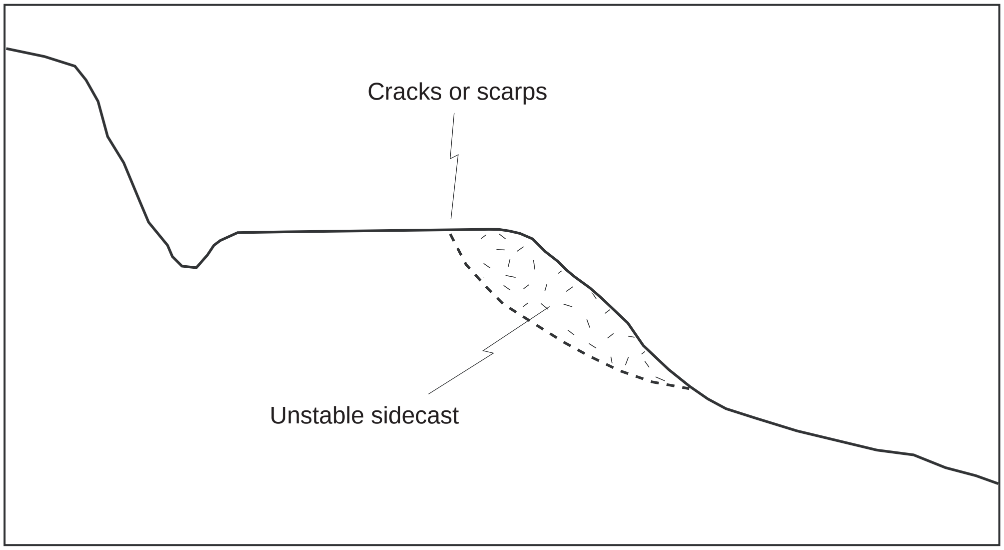
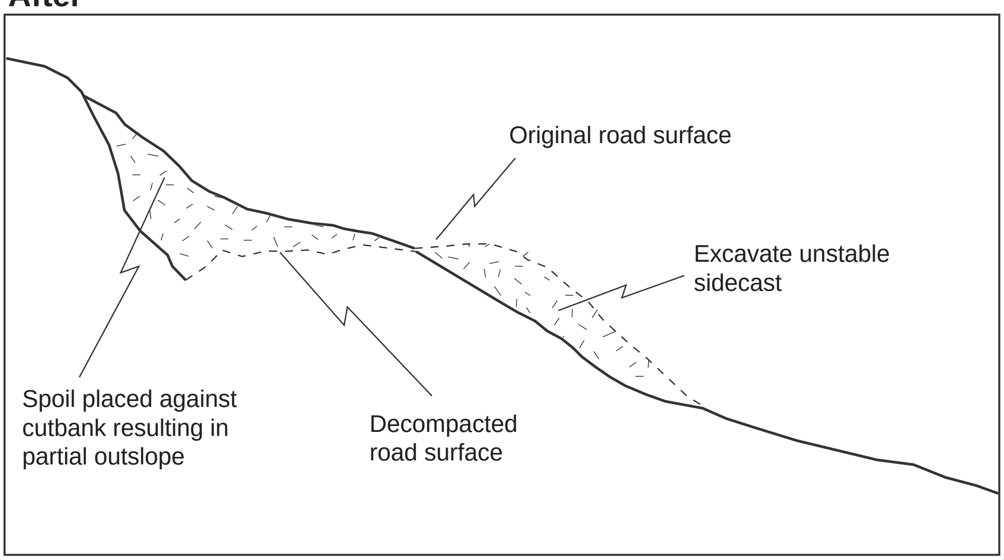
Typical Excavation of Unstable Fillslope on a Decommissioned Road

Before



After



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APPENDIX D

Geologic and geomorphic maps of the Hare Creek and Little North Fork Big River areas, Mendocino County, California

Unit descriptions to accompany the geologic and geomorphic maps:

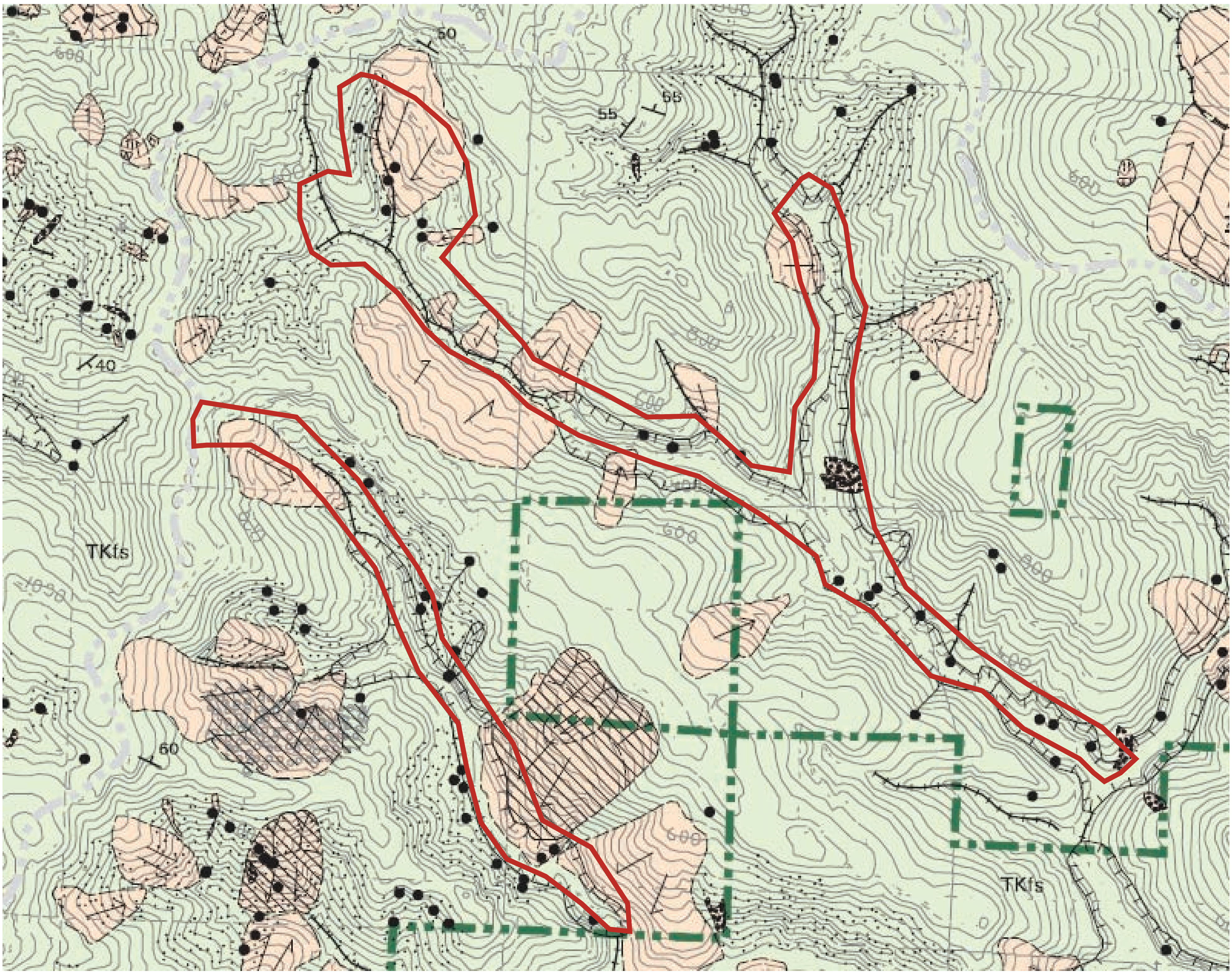
Q - RECENT ALLUVIUM- Holocene. Interbedded gravel, sand, silt and clay within active stream channels and adjoining flood plains

Qods - OLDER DUNES- Pleistocene. Well-sorted, semi-consolidated, fine-to-medium-grained sand overlying various marine terrace deposits

Qctu – CHANNEL AND TERRACE DEPOSITS, Undifferentiated: Holocene and Pleistocene. Undifferentiated active stream channel, active floodplain, and immediately adjacent fluvial terrace deposits. Locally consisting of loose, unconsolidated, and uncemented silt, sand, and gravel. This unit may also include some local deposits of reworked sedimentresulting from anthropogenic disturbances from past timber harvesting related to breaching of logging dams (splash, crib, and frame dams) between approximately 1860 and 1924 (Dates established by Jackson, 1991).

Qmts - MARINE TERRACE DEPOSITS UNDIFFERENTIATED- Pleistocene. Deposits generally consist of well-sorted sand with minor gravel and have coarser textures near major drainages; may include some dune sands.

TKfs - COASTAL BELT FRANCISCAN: Tertiary-Cretaceous. Broken formation consisting of light-colored, well-cemented to deeply weathered and sheared, clastic sedimentary rocks; includes arkosic sandstone, pebble conglomerate, and shale, with smaller amounts of greenstone, chert, and limestone. Characterized by coherent and some disjointed bedrock blocks, of various sizes (up to a city block and larger), separated by broad shear zones and faulting, locally folded, resulting in a relatively coherent bedrock terrane.



Legend

See accompanying text for unit descriptions

Assessment Areas

Scale

1 mile

Rock slide (rotational / translational landslide): Slope movement with bedrock as its primary source material. This class of failure includes rotational and translational landslides; relatively cohesive slide masses with failure planes that are deep-seated in comparison to debris slides of similar areal extent. The slide plane is curved in a rotational slide. Movement along a planar joint or bedding surface may be referred to as translational. Complex versions with combinations of rotational heads and translational movement or earthflows downslope are common. indicates a scarp; arrows show direction of movement; queried where the presence of the slide is uncertain. Boundary is solid where historically active, dashed where dormant, queried where uncertain.

Earthflow: Slow to rapid movement of mostly fine-grained soil with some rocky debris in a semi-viscous, highly plastic state. After initial failure, the mass may flow or creep seasonally in response to changes in groundwater level. These types of slope failures often include complexes of nested rotational slides and deeply incised gullies. Boundaries are usually indistinct. indicates a scarp; arrow indicates direction of movement. Queried where the presence of the slide is uncertain. Boundary is solid where historically active, dashed where dormant, queried where uncertain.

Debris slide: Mass of unconsolidated rock, colluvium, and coarse-grained soil that has moved slowly to rapidly downslope along a relatively steep, shallow, translational failure plane. Debris slides form steep, unvegetated scars in the head region and irregular, hummocky deposits in the toe region. Scars commonly ravel and remain unvegetated for several seasons depending on slope aspect. Queried where the presence of the slide is uncertain. Boundary is solid where historically active, dashed where dormant, queried where uncertain.

Debris flow / Torrent track: Long stretches of bare ground that have been scoured and eroded to bedrock by extremely rapid movement of water-laden debris. Debris flows are commonly triggered by debris sliding in the source area during high intensity rains. Debris is often deposited downslope as a tangled mass of organic material in a matrix of rock and soil; debris may be reworked and incorporated into subsequent events; lack of vegetation indicates recent activity. Queried where the presence of the slide is uncertain.

Small landslide: Landslide too small to delineate at 1:24,000 scale (typically less than 1/5 acre in area or less than 150 feet in length).

Disrupted ground: Irregular ground surface caused by complex landsliding processes resulting in features that are indistinguishable or too small to delineate individually at 1:24,000 scale; also may include areas affected by downslope creep, expansive soils, and/or gully erosion. Boundaries are usually indistinct.

Debris slide slope / source area: A geomorphic feature characterized by steep, usually well vegetated slopes that appear to have been sculpted by numerous debris slides and debris flows. Upper reaches (source areas) of these slopes are often tightly concave and very steep. Soil and colluvium atop bedrock may be disrupted by active debris slides and debris flows. Slopes near the angle of repose may be relatively stable except where weak bedding planes, bedrock joints and fractures parallel the slope.

Inner gorge: A geomorphic feature consisting of steep slopes adjacent to channels. The gorge typically is created by accelerated downcutting in response to regional uplift. It is defined as an area of streambank between the channel and the first break in slope. Line is queried where uncertain, or broken into segments to represent a stretch of discontinuous inner gorge too small to accurately represent at 1:24,000 scale. One-sided hachures indicate inner gorge on one side of channel only; hachures point downslope.

Shear zone: Fault zone without distinct mappable fault trace.

Lithologic contact: Solid where location is certain, dashed where approximately located or inferred, dotted where concealed, and queried where continuation or existence is uncertain.

Fault: Solid where location is certain, dashed where approximately located or inferred, dotted where concealed, and queried where continuation or existence is uncertain.

Anticline: Solid where known, dashed where approximate.

Syncline: Solid where known, dashed where approximate.

Lineament: Linear feature of unknown origin noted on aerial photographs.

Watershed boundary

Public land survey system

Watercourse

Road, street, trail

Strike and dip of bedding

Strike of vertical bedding

Outcrop

Wet area

Spring

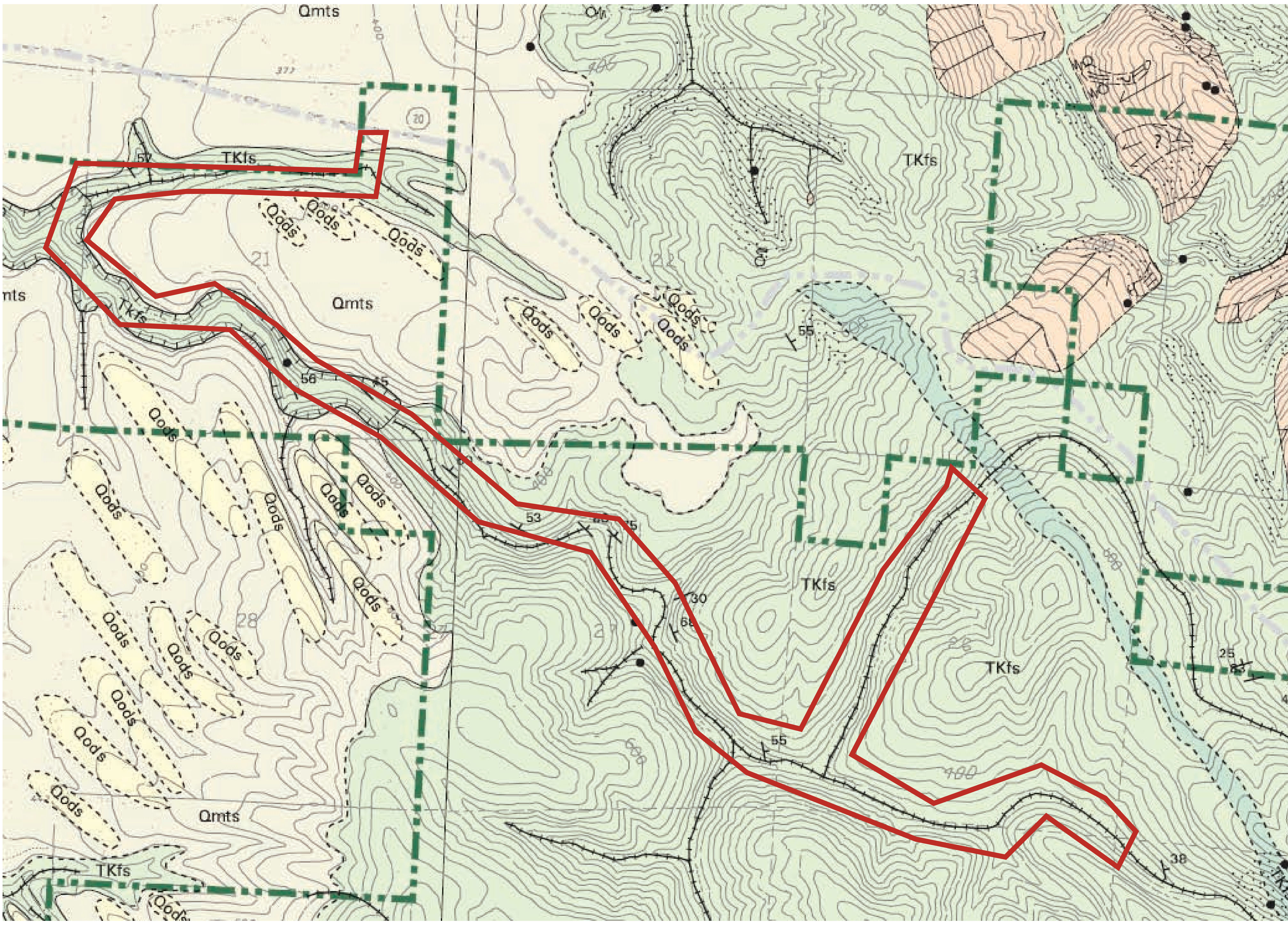
Quarry

City or town

All geologic mapping from CGS, 2005

N

Map D-1. Geologic and Geomorphic map of the Bunker and Thompson Gulch watershed assessment area, Mendocino County, California.



Legend

See accompanying text for unit descriptions

Scale

1 mile

Assessment Area

Rock slide (rotational / translational landslide): Slope movement with bedrock as its primary source material. This class of failure includes rotational and translational landslides; relatively cohesive slide masses with failure planes that are deep-seated in comparison to debris slides of similar areal extent. The slide plane is curved in a rotational slide. Movement along a planar joint or bedding surface may be referred to as translational. Complex versions with combinations of rotational heads and translational movement or earthflows downslope are common. indicates a scarp; arrows show direction of movement; queried where the presence of the slide is uncertain. Boundary is solid where historically active, dashed where dormant, queried where uncertain.

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Disrupted ground: Irregular ground surface caused by complex landsliding processes resulting in features that are indistinguishable or too small to delineate individually at 1:24,000 scale; also may include areas affected by downslope creep, expansive soils, and/or gully erosion. Boundaries are usually indistinct.

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Lineament: Linear feature of unknown origin noted on aerial photographs.

Watershed boundary

Public land survey system

Watercourse

Road, street, trail

Strike and dip of bedding

Strike of vertical bedding

Outcrop

Wet area

Spring

Quarry

City or town

All geologic mapping from CGS, 2005

N

Map D-2. Geologic and Geomorphic map of the Hare Creek watershed assessment area, Mendocino County, California.

Summary Report

Lawson Road Assessment, Upper Rancheria Creek, Navarro River Watershed, Mendocino County, California

prepared for

Mendocino County Resource Conservation District
and
California Coastal Conservancy

by

Pacific Watershed Associates
Arcata, California
(707) 839-5130
March, 2004

Summary Report
Lawson Road Assessment
Mendocino County, California

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List of Maps

PACIFIC WATERSHED ASSOCIATES

Summary Report
Lawson Road Assessment
Mendocino County, California

prepared by
Pacific Watershed Associates

for
Mendocino County Resource Conservation District
and
California Coastal Conservancy

Background
The Lawson property is located in southern Mendocino County, California. Roads on the Lawson property traverse several major tributaries to Rancheria Creek, a tributary of the Navarro River, south of the communities of Boonville and Yorkville (Map 1). The Navarro River, is an important anadromous stream to the California North Coast, supporting Coho salmon and steelhead trout.

Lawson Road Assessment and Implementation
Perhaps the most important element needed for long term protection and restoration of salmonid habitat, and the eventual recovery of salmonid populations in Upper Rancheria Creek, is the reduction of accelerated erosion and sediment delivery to the channel system from upland erosion. This summary report describes the watershed assessment and inventory process that was employed on Lawson Road.

The summary report also serves as a prioritized plan-of-action for cost-effective erosion control and erosion prevention treatments for Lawson Road. When implemented and employed in combination with protective road maintenance and land use practices, the proposed project is expected to significantly contribute to the long term protection and improvement of salmonid habitat in the basin. The implementation of erosion control and erosion prevention work is an important step towards protecting and restoring watersheds and their anadromous fisheries (especially where sediment input is a limiting or potentially limiting factor to fisheries production, as is thought to be the case for the Navarro River (U.S. Environmental Protection Agency, 2000).

Road systems are now widely recognized throughout the north and central coast region as one of the most significant, and the most easily controlled, sources of sediment production and delivery to stream channels. Upper Rancheria Creek is underlain by erodible and potentially unstable geologic substrate, and field observations suggest that roads have been a significant source of accelerated sediment production in the watershed. In Upper Rancheria Creek, as elsewhere, the disturbance caused by excess sediment input to stream channels during large rainfall events is perhaps one of the most significant factors affecting salmonid populations. Unlike many watershed improvement and restoration activities, erosion prevention and "storm-proofing" of road systems has an immediate benefit to the streams and aquatic habitat of the basin. It helps ensure that the biological productivity of the watershed's streams is not impacted by future human-caused erosion, and that future storm runoff can cleanse the streams of accumulated coarse and fine sediment, rather than depositing additional sediment from managed areas. Sites targeted as high or moderate treatment immediacy within the Lawson road assessment area have been identified as priority sites for implementation so that road fill failures, stream crossing washouts and stream diversions do not further degrade the stream system. The road assessment identified all recognizable current and future sediment sources from approximately 12.4 miles of roads on the Lawson property. The primary objective of the proposed road upgrading is to implement cost-effective erosion control and erosion prevention work on high, moderate and low priority sites that were identified as a part of this inventory.

Project Description

The project involved a complete inventory of approximately 12.4 miles of roads on the Lawson property. Technically, this assessment is neither an erosion inventory nor a road maintenance inventory. Rather, it is an inventory of sites where there is a potential for future sediment delivery to the stream system that could impact fish bearing streams in the watershed. Sites, as defined in this assessment, include locations where there is direct evidence that future erosion or mass wasting could be expected to deliver sediment to a stream channel. Sites of past erosion were not inventoried unless there was a potential for additional future sediment delivery. Similarly, sites of future erosion that were not expected to deliver sediment to a stream channel were not inventoried as part of this assessment, but their location was mapped on topographic base maps.

Inventoried sites generally consisted of stream crossings, potential landslides, and gullies below ditch relief culverts and long sections of uncontrolled road and ditch surface runoff which currently discharge to the stream system. For each identified existing or potential erosion source, a database form was filled out and the site was mapped on mylar overlays over 1:10,300 and 1:11,500 scale topographic maps. The database form (Appendix A) contained questions regarding the site location, the nature and magnitude of existing and potential erosion problems, the likelihood of erosion or slope failure and recommended treatments to eliminate the site as a future source of sediment delivery.

The erosion potential (and percentage of sediment delivery to stream channels) was estimated for each major problem site or potential problem site. The future expected volume of sediment to be eroded and the volume to be delivered to streams was estimated for each site. The data provides quantitative estimates of how much material could be eroded and delivered in the future, if no erosion control or erosion prevention work is performed. In a number of locations, especially at stream diversion sites, actual sediment loss could easily exceed field predictions. All sites were assigned a treatment priority, based on their potential to deliver deleterious quantities of sediment to stream channels in the watershed and the cost-effectiveness of the proposed treatment.

Inventory Results

Approximately 12.4 miles of road was inventoried for future sediment sources within the Lawson road assessment area. Inventoried road-related erosion sites within the assessment are all categorized as upgrade sites - defined as sites on maintained open roads that are to be retained for access. Virtuallyall future road-related erosion and sediment yield in the Lawson road assessment area is expected to come from three sources: 1) erosion at or associated with stream crossings (from several possible causes), 2) potential road fill failures (landslides) and 3) road surface and ditch erosion.

A total of 100 sites with sediment delivery were identified along the roads in the Lawson road assessment area (Table1 and Map 2). These sites were identified as having a high, high-moderate, moderate, moderate-low or low potential of future sediment delivery to Upper Rancheria Creek. Sites include 72 stream crossings, 17 ditch relief culverts, 2 potential fill failures (landslides) and 9 "other" sites. From the total 100 inventoried sites, 97 (97%) have been recommended for erosion control and erosion prevention treatment. In addition, 45% of the 12.4 miles of the Lawson road network surveyed is currently connected to stream crossings and delivering fine sediment and road surface runoff to streams.

Stream crossings - Seventy-two (72) stream crossings were inventoried within the Lawson Road assessment area including 48 culverted stream crossings, 16 unculverted fill crossings, 1 armored fill crossing, 5 ford crossings and 2 bridges. An unculverted fill crossing refers to stream crossings with no formal drainage structure to carry the flow through the road prism. Flow is carried over the road surface and is diverted down the road, to the inboard ditch, or onto the native hillslope at some location down the road. The unculverted fill crossings are located at small streams that exhibit flow only in the larger runoff events.

Of the 72 stream crossings identified in the assessment, 69 have been recommended for erosion control and erosion prevention treatment. Approximately 2,512 yds^3 of future road-related sediment yield in the Lawson road assessment area could originate from erosion at stream crossings if they are not treated (Table 1). This amounts to nearly 18% of the total expected future sediment yield from the road. The most common problems which can lead to erosion at stream crossings include: 1) crossings with undersized drainage structures, 2) crossings with no drainage structures and 3) stream crossings with a diversion potential. The sediment delivery from stream crossing sites is always classified as 100% because any sediment eroded at the crossing site is delivered directly to the channel. Any sediment which is delivered to small ephemeral streams will eventually be delivered to downstream fish-bearing stream channels of Upper Rancheria Creek.

At stream crossings, the largest volumes of future erosion can occur when drainage structures plug or when flood runoff spills onto or across the road and diverts down the road. When stream flow goes over the fill, part or all of the stream crossing fill may be eroded. Alternately, when flow is diverted down the road, either on the road bed or in the ditch (instead of spilling over the fill and back into the same stream channel), the crossing is said to have a "diversion potential" and the road bed, hillslope and/or stream channel that receives the diverted flow can become deeply gullied or destabilized. These hillslope gullies can be quite large and can deliver significant quantities of sediment to stream channels. Alternately, diverted stream flow which is discharged onto steep, potentially unstable slopes can also trigger large hillslope landslides. Forty-nine (49) stream crossings identified in the Lawson road assessment area have a diversion potential and 16 are currently diverted (Table 1). Treatment for stream crossings diversions are straight forward and require the construction of a broad "critical dip" at the down-road hinge line of the stream crossing to re-direct flow back into its natural drainage.

Four stream crossings were determined to be vertical or velocity barriers to fish passage. These crossings prevent salmonids from accessing valuable fish habitat upstream. The prescribed treatment of these sites will eliminate the fish barrier and allow salmonids increased access to habitat and potential spawning grounds. Treatment of these sites could be a valuable improvement to anadromous fish populations in Rancheria creek.

Table 1. Site classification and sediment yield from all inventoried sites with future sediment delivery in the Lawson road assessment area, Mendocino County, California.

Site Type	Number of sites or road miles inventoried	Number of sites or road miles to treat	Future yield (yds^3)	Stream crossings w/ a diversion potential (#)	Streams currently diverted (#)	Stream culverts likely to plug (plug potential rating = high or moderate)
Stream crossings	72	69	2,512	49	16	19
Ditch relief culverts	17	17	70	-	-	-
Landslides	2	2	8	-	-	-
Other	9	9	335	-	-	-
Total (all sites)	100	97	2,925	49	16	19
Persistent surface erosion[1]	5.62	5.50	10,750	-	-	-
Totals	**100**	**97**	**13,675**	**49**	**16**	**19**

[1] Assumes 25' wide road prism and cutbank contributing area, and 0.2' of road/cutbank surface lowering per decade for two decades.

Sixty-nine (69) stream crossings inventoried in the Lawson road assessment area will need to be upgraded for the road to be considered "storm-proofed." The roads in this assessment area was constructed on steep hillslopes and gentle prairie slopes and stream crossings are typically diverted, have no drainage structure or are under-designed for the 100-year storm flow. Preventative treatments include such measures as constructing critical dips (rolling dips) at stream crossings to prevent stream diversions, installing larger culverts wherever culverts are under-designed for the 100-year storm flow (or where they are prone to plugging) or installing properly sized culverts at crossings with no drainage structure.

Ditch relief culverts - Only those ditch relief culverts that currently deliver or will potentially deliver sediment to streams in the future were inventoried in this project. Seventeen (17) ditch relief culverts with potential sediment delivery were identified and account for 17% of the inventoried sites in the Lawson road assessment area. Gully erosion can occur below ditch relief culvert outlets due to excessive road and/or ditch contribution to the inlet. Gully erosion can also occur as a result of poor installation techniques such as shotgunned outlets or the culvert being placed too high in the fill without functional downspouts. Ditch relief culverts are expected to deliver approximately 70 yds^3 of sediment to Upper Rancheria Creek and its tributaries in the future.

All 17 ditch relief culverts identified in the assessment have been recommended for erosion control and erosion prevention treatment. Correcting or reducing sediment delivery associated with ditch relief culverts generally involves reducing and dispersing excessive ditch flow by installing additional ditch relief culverts, installing rolling dips and outsloping roads. Reducing outlet erosion below these sites involves installing functional downspouts as well as replacing ditch relief culverts deeper in the fill.

Landslides - Only those landslides with a potential for sediment delivery to a stream channel were inventoried. A total of two "landslides" were identified in the assessment and these account for less than 1% of the total expected future sediment delivery volume in the Lawson road assessment area (Table 1). Most of the potential landslide sites were found along the road where material had been sidecast during road construction and recent road maintenance grading and now show signs of instability. These sites were identified using field evidence such as road surface cracks, scarps or J-shaped trees.

The two landslides identified within the Lawson road assessment area have been recommended for erosion control and erosion prevention treatment. Potential landslides are expected to deliver nearly 8 yds^3 of sediment to Upper Rancheria Creek and its tributaries in the future if they are not treated. Correcting or preventing potential landslides associated with the road is relatively straight-forward, and involves the physical excavation of potentially unstable road fill and sidecast materials. There are a number of potential landslide sites located on the road that did not, or will not, deliver sediment to streams. These sites were not inventoried using data sheets due to the lack of expected sediment delivery to a stream channel. They are generally shallow and of small volume, or located far enough away from an active stream such that delivery is unlikely to occur. For reference, all landslide sites were mapped on the mylar overlay of the field inventory maps, but only those with the potential for future sediment delivery were inventoried using a datasheet.

Persistent surface erosion - We measured approximately 5.62 miles of road surface and/or road ditch (representing 45% of the 12.4 mile Lawson road assessment area) which currently drain directly to streams, and delivers ditch and road runoff and fine sediment to stream channels. The roads in this area are said to be "hydrologically connected" to the stream channel network. When these roads are being actively maintained and used for access, they represent a potentially important source of chronic fine sediment delivery to the stream system throughout the year.

Of the 5.62 miles of road surface and/or ditch contribution, 5.50 miles have been recommended for treatment. From these "connected" road segments, we calculated approximately 10,750 yds^3 of sediment will be delivered to Upper Rancheria Creek and its tributaries over the next 20 years if no efforts are made to change road drainage patterns (Table 1)[1]. This will occur through a combination of 1) cutbank erosion delivering sediment to the ditch triggered by dry ravel, surface erosion, freeze-thaw processes, cutbank landslides and brushing/grading practices, 2) inboard ditch erosion and sediment transport, 3) mechanical pulverizing and wearing down of the road surface, and 4) erosion of the road surface during wet weather periods.

Relatively straightforward erosion prevention treatments can be applied to upgrade road systems to prevent fine sediment from entering stream channels. These treatments generally involve dispersing road runoff and disconnecting road surface and ditch drainage from the natural stream channel network. Road surface treatments include the installation of rolling dips, road surface outsloping and/or installation of additional ditch relief culverts prior to rocking road surfaces.

Treatment Priority

An inventory of future or potential erosion and sediment delivery sites is intended to provide information which can guide long range transportation planning, as well as identify and prioritize erosion prevention and erosion control activities within the Lawson road assessment area. Not all of the sites that have been recommended for treatment have the same priority, and some can be treated more cost effectively than others. Treatment priorities are evaluated on the basis of several factors and conditions associated with each potential erosion site:

1) the expected volume of sediment to be delivered to streams (yds^3),
2) the potential or "likelihood" for future erosion (high, moderate, low),
3) the "urgency" of treating the site (treatment immediacy - high, moderate, low),
4) the ease and cost of accessing the site for treatments, and
5) recommended treatments, logistics and costs.

The ***erosion potential*** of a site is a professional evaluation of the likelihood that erosion will occur during a future storm event. Erosion potential is an estimate of the potential for additional erosion, based on field observations of a number of local site conditions. Erosion potential was evaluated for each site, and expressed as "High", "Moderate" or "Low." The evaluation of erosion potential is a subjective estimate of the probability of erosion, and not an estimate of how much erosion is likely to occur. It is based on the age and nature of direct physical indicators and evidence of pending instability or erosion. The likelihood of erosion (erosion potential) and the volume of sediment expected to enter a stream channel from future erosion (sediment delivery) play significant roles in determining the treatment priority of each inventoried site (see "treatment immediacy," below). Field indicators that are evaluated in determining the potential for sediment delivery include such factors as slope steepness, slope shape, distance to the stream channel, soil moisture and evaluation of the erosional processes. The larger the potential future

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[1] The applied, average rate of surface lowering on cutbanks and along road beds (i.e. 0.2 feet/decade) is based on observed retreat or erosion rates in the Upper Rancheria watershed, and on un-published data from sediment budget studies on similar geologies in the Redwood Creek watershed, Humboldt County (Redwood National Park, unpublished data).

contribution of sediment to a stream, the more important it becomes to closely evaluate its potential for cost-effective treatment.

Treatment immediacy (treatment priority) is a professional evaluation of how important it is to "quickly" perform erosion control or erosion prevention work. It is also defined as "High", "Moderate" and "Low" and represents both the severity and urgency of addressing the threat of sediment delivery to downstream areas. An evaluation of treatment immediacy considers erosion potential, future erosion and delivery volumes, the value or sensitivity of downstream resources being protected, and treatability, as well as, in some cases, whether or not there is a potential for an extremely large erosion event occurring at the site (larger than field evidence might at first suggest). If mass movement, culvert failure or sediment delivery is imminent, even in an average winter, then treatment immediacy might be judged "High". Treatment immediacy is a summary, professional assessment of a site's need for immediate treatment. Generally, sites that are likely to erode or fail in a normal winter, and that are expected to deliver significant quantities of sediment to a stream channel, are rated as having a high treatment immediacy or priority.

Evaluating Treatment Cost-Effectiveness

Treatment priorities are developed from the above factors, as well as from the estimated cost-effectiveness of the proposed erosion control or erosion prevention treatment. Cost-effectiveness is determined by dividing the cost ($) of accessing and treating a site, by the volume of sediment prevented from being *delivered* to local stream channels. For example, if it would cost $2000 to develop access and treat an eroding stream crossing that would have delivered 150 yds^3 (had it been left to erode), the predicted cost-effectiveness would be $13/yds^3 ($2000/150 yds^3).

To be considered for priority treatment a site should typically exhibit: 1) potential for sediment delivery to a stream channel (with the potential for transport to a fish-bearing stream), 2) a high or moderate treatment immediacy and 3) a predicted cost-effectiveness value averaging in the general range of approximately $7 to $15/yd^3, or less.[2] Treatment cost-effectiveness analysis is often applied to a group of sites (rather than on a single site-by-site basis) so that only the most cost-effective groups of sites or projects are undertaken. During road decommissioning, groups of sites are usually considered together since there will only be one opportunity to treat potential sediment sources along the road. In this case, cost-effectiveness may be calculated for entire roads or road reaches that fall into logical treatment units.

[2] The cost-effectiveness values of $7 to $15/yd^3, or less, was developed by the CDF&G in 1996 based on cost estimates to treat and upgrade road erosion sites along roads in the northern California counties of Humboldt, Trinity, Del Norte and Mendocino. Several factors indicate that in the San Francisco Bay Area counties, a more appropriate cost-effectiveness value should be between $10 to $25/yd^3 saved or prevented from entering a stream channel. The acceptability of the proposed revision in cost-effectiveness values is based on the following considerations: 1) numerous road assessments PWA has performed over the last 5 years in the greater Bay Area from Sonoma to Monterey Counties, where the cost-effectiveness values frequently exceed $15/yd^3 saved, 2) heavy equipment rental rates in the Bay Area counties on average, exceed the north coast counties by 25% to 50%, 3) the cost-effectiveness values established by CDF&G over 6 years ago have not been adjusted for cost-of-living rate changes, whether based on inflation or the higher cost of living in the greater Bay Area, and 4) the vast majority of upland road projects in the Bay Area counties are conducted at prevailing wage rates compared to owner-operator rates charged on similar projects in the north coast counties.

Cost-effectiveness can be used as a tool to prioritize potential treatment sites throughout a sub-watershed (Weaver and Sonnevil, 1984; Weaver and others, 1987). It assures that the greatest benefit is received for the limited funding that is typically available for protection and restoration projects. Sites, or groups of sites, that have a predicted marginal cost-effectiveness value (>$20/yd^3), or are judged to have a lower erosion potential or treatment immediacy, or low sediment delivery volumes, are less likely to be treated as part of the primary watershed protection and "erosion-proofing" program. However, these sites should be addressed during future road reconstruction (when access is reopened into areas for future management activities), or when heavy equipment is performing routine maintenance or restoration at nearby, higher priority sites.

Types of Prescribed Heavy Equipment Erosion Prevention Treatments

Forest roads can be storm-proofed by one of two methods: upgrading or decommissioning (Weaver and Hagans, 1999). Upgraded roads are kept open and are inspected and maintained. Their drainage facilities and fills are designed or treated to accommodate or withstand the 100-year storm. In contrast, decommissioned roads are closed and no longer require maintenance. The goal of storm proofing is to make the road as "hydrologically invisible" as is possible; that is, to disconnect the road from the stream system and thereby reduce fine sediment and protect aquatic habitat. The characteristics of storm-proofed roads, including those which are either upgraded or decommissioned, are depicted in Figure 1.

Road upgrading involves a variety of treatments used to make a road more resilient to large storms and flood flows. The most important of these include stream crossing upgrading (especially culvert up-sizing to accommodate the 100-year storm flow and debris in transport, and to eliminate stream diversion potential), removal of unstable sidecast and fill materials from steep slopes, and the application of drainage techniques to improve dispersion of road surface runoff. Road drainage techniques include berm removal, road outsloping, rolling dip construction, and/or the installation of ditch relief culverts. Along some low strength road routes within the Lawson road network, re-rocking the road following rolling dip construction and road outsloping or insloping efforts will be necessary.

Recommended Treatments

Basic treatment priorities and prescriptions were formulated concurrent with the identification, description and mapping of potential sources of road-related sediment delivery. Table 2 and Map 3 outline the treatment priorities for all 97 inventoried sites with future sediment delivery that have been recommended for treatment within the Lawson road assessment area. Of the 97 sites, 7 sites were identified as having a high treatment immediacy with a potential sediment delivery of approximately 972 yds^3. Seventeen (17) sites were listed with a high-moderate treatment immediacy and these account for up to 2,747 yds^3. Thirty-one (31) sites were listed with a moderate treatment immediacy and these account for 4,667 yds^3. Thirty (30) sites were listed with a moderate low treatment immediacy and these account for nearly 3,793 yds^3.
Finally, 12 sites were listed with a low treatment immediacy and account for approximately 1,496 yds^3 of future sediment delivery from the road.

FIGURE 1. CHARACTERISTICS OF STORM-PROOFED ROADS

The following abbreviated criteria identify common characteristics of "storm-proofed" roads. Roads are "storm-proofed" when sediment delivery to streams is strictly minimized. This is accomplished by dispersing road surface drainage, preventing road erosion from entering streams, protecting stream crossings from failure or diversion, and preventing failure of unstable fills which would otherwise deliver sediment to a stream. Minor exceptions to these "guidelines" can occur at specific sites within a forest or rural road system.

STREAM CROSSINGS

- ✔ all stream crossings have a drainage structure designed for the 100-year flow
- ✔ stream crossings have no diversion potential (functional critical dips are in place)
- ✔ stream crossing inlets have low plug potential (trash barriers & graded drainage)
- ✔ stream crossing outlets are protected from erosion (extended, transported or dissipated)
- ✔ culvert inlet, outlet and bottom are open and in sound condition
- ✔ undersized culverts in deep fills (> backhoe reach) have emergency overflow culvert
- ✔ bridges have stable, non-eroding abutments & do not significantly restrict 100-year flood flow
- ✔ fills are stable (unstable fills are removed or stabilized)
- ✔ road surfaces and ditches are "disconnected" from streams and stream crossing culverts
- ✔ decommissioned roads have all stream crossings completely excavated to original grade
- ✔ Class 1 (fish) streams accommodate fish passage

ROAD AND LANDING FILLS

- ✔ unstable and potentially unstable road and landing fills are excavated (removed)
- ✔ excavated spoil is placed in locations where eroded material will not enter a stream
- ✔ excavated spoil is placed where it will not cause a slope failure or landslide

ROAD SURFACE DRAINAGE

- ✔ road surfaces and ditches are "disconnected" from streams and stream crossing culverts
- ✔ ditches are drained frequently by functional rolling dips or ditch relief culverts
- ✔ outflow from ditch relief culverts does not discharge to streams
- ✔ gullies (including those below ditch relief culverts) are dewatered to the extent possible
- ✔ ditches do not discharge (through culverts or rolling dips) onto active or potential
- ✔ decommissioned roads have permanent road surface drainage and do not <u>rely</u> on ditches

Table 2. Treatment priorities for all inventoried sediment sources in the Lawson road assessment area, Mendocino County, California

Treatment Priority	Upgrade sites (# and site #)	Problem	Future sediment delivery (yds³)
High	7 (site #: 111, 142, 145, 147, 163, 187, 193)	5 stream crossings, 1 ditch relief culvert, 1 other	972
Moderate High	17 (site #: 107, 112, 118, 140, 144, 154, 158, 160, 168, 173, 179, 188, 192, 195, 197, 198, 199)	11 stream crossings, 1 ditch relief culvert, 1 landslide, 4 other	2,747
Moderate	31 (site #: 103, 104, 105, 106, 120, 123, 125, 128, 129, 130, 131, 134, 135, 139, 143, 146, 150, 151, 156, 164, 169, 171, 172, 176, 182, 183, 185, 186, 191, 194, 196)	21 stream crossings, 8 ditch relief culverts, 2 other	4,667
Moderate Low	30 (site #: 100, 102, 108, 109, 110, 113, 114, 115, 117, 119, 121, 122, 127, 132, 133, 136, 137, 148, 149, 152, 153, 161, 162, 166, 177, 178, 180, 184, 189, 190)	23 stream crossings, 6 ditch relief culverts, 1 landslide	3,793
Low	12 (site #: 101, 116, 124, 126, 138, 155, 159, 165, 167, 171, 175, 181)	9 stream crossings, 1 ditch relief culvert, 2 other	1,496
Total	**97**	**69 stream crossings, 16 ditch relief culverts, 2 landslides, 10 other**	**13,675**

Table 3 summarizes the proposed treatments for sites inventoried within the Lawson road assessment area. The database, as well as the field inventory sheets provide details of the treatment prescription for each site. Most treatments require the use of heavy equipment, including an excavator, dozer, dump truck and/or grader. Some hand labor is required at sites needing new culverts, downspouts, and applying seed, plants and mulch following ground disturbance activities. A total of 31 critical dips have been recommended to prevent diversions at streams that currently have a diversion potential. A total of 39 culverts are recommended for replacement or for installation at stream crossings. It is estimated that erosion prevention work will require the excavation and removal of approximately 217 yds³ at 11 sites. Approximately 63% of the volume is associated with upgrading stream crossings, 5% of the volume excavated is a result of excavating future landslides and 12% of the volume excavated is a result of "other" sites. A total of 420 yds³ of 0.25 to 1.25 foot diameter, mixed and clean rip-rap sized rock will be needed as armor for stream crossing fillslopes and to construct armored fill crossings and fords. We have recommended 88 rolling dips and 19 ditch relief culverts be installed at selected locations along the road, at spacings dictated by the steepness of the road.

Table 3. Recommended treatments along all inventoried roads in the Lawson road assessment area, Mendocino County, California.

Treatment	No.	Comment	Treatment	No.	Comment
Critical dip	31	To prevent stream diversions	Install rolling dips	88	Install rolling dips to improve road drainage
Install CMP	3	Install a CMP at an unculverted fill crossing	Install ditch relief CMP	8	Install ditch relief culverts to improve road surface drainage
Replace CMP	36	Upgrade an undersized CMP	Replace ditch relief CMP	11	Replace ditch relief culverts to improve road surface drainage
Excavate soil	11	Typically fillslope & crossing excavations; excavate a total of 217 yds^3	Rock road surface	94	Rock or re-rock road surface using 1,242 yds^3 road rock at site specific locations
Wet crossing	19	Install 15 armored fill and ford crossings using 225 yds^3 of rip-rap and armor	Remove berm	3	Remove 370' of berm to prevent concentration of flow
Trash rack	2	Install trash rack	Clean/cut ditch	4	Clean existing or cut new inboard ditch for 270'
CMP downspout	4	Install full-round downspout to CMP	Outslope and remove ditch	3	Outslope road and remove inboard ditch for 590'
Armor fill face	12	Rock armor to protect fillslope using 166 yds^3 of rock	Other treatment	1	Miscellaneous treatment
Armor ditch	2	Rock armor to protect ditch using 27 yds^3 of rock	No treatment recommended	3	Assessed sites where no treatment was recommended
Armor headcut	1	Rock armor to protect headcut using 2 yds^3 of rock			
Clean CMP	3	Clean debris from CMP inlet or outlet			

Equipment Needs and Costs

Table 4 lists the expected heavy equipment and labor requirements, by treatment immediacy, to treat all the specific inventoried sites as well as the 5.50 miles of contributing road bed and ditch.

Treatments for the 97 sites identified with future sediment delivery within the Lawson road assessment area will require approximately 299 hours of excavator time and 234 hours of tractor time to complete all prescribed upgrading, erosion control and erosion prevention work (Table 4). Excavator and tractor work is not needed at all the sites that have been recommended for treatment and, likewise, not all the sites will require both a tractor and an excavator.

Approximately 28 hours of dump truck time has been listed for work in the assessment area for enhauling excavated spoil from stream crossings, landslide, and "other" sites where local disposal sites are not available.

Approximately 225 hours of labor time is needed for a variety of tasks such as installing new culverts, rock armor, filter fabric, downspouts and other miscellaneous tasks. An additional 29 hours of labor are allocated for mulching and planting activities. A water truck will be required for 74 hours to wet down material during road surface and stream crossing upgrades.

Table 4. Estimated heavy equipment and labor requirements for treatment of all inventoried sites with future sediment delivery, Lawson road assessment area, Mendocino County, California.

Treatment Immediacy	Site (#)	Excavated Volume (yds^3)	Excavator (hrs)	Tractor (hrs)	Grader (hrs)	Dump truck (hrs)	Labor (hrs)
High, High/Moderate	24	867	83	91	1	18	43
Moderate, Low/Moderate	61	1,465	196	126	1	10	169
Low	12	98	20	17	1	0	13
Total	**97**	**2,430**	**299**	**234**	**3**	**28**	**225**

Estimated costs for erosion prevention treatments Prescribed treatments are divided into two components: a) site specific erosion prevention work identified during the road inventory, and b) control of persistent sources of road surface, ditch and cutbank erosion and associated sediment delivery to streams. The total costs for road-related erosion control at sites with future sediment delivery is estimated at approximately $222,705 for an average cost-effectiveness value of approximately $16.29 per cubic yard of sediment prevented from entering Upper Rancheria Creek. (Table 5).

Overall site specific erosion prevention work- Equipment needs for site specific erosion prevention work at sites with future sediment delivery are expressed in the database, and summarized in Tables 4 and 5, as direct excavation times, in hours, to treat all sites. These hourly estimates include only the time needed to treat each of the sites, and do not include travel time between work sites, times for basic road surface treatments that are not associated with a specific "site," or the time needed for work conferences at each site. These additional times are accumulated as "logistics" and must be added to the work times shown in Table 4 to determine

Table 5. Estimated logistic requirements and costs for road-related erosion control and erosion prevention work on all inventoried sites with future sediment delivery in the Lawson road assessment area, Mendocino County, California.

Cost Category		Cost Rate[1] ($/hr)	Estimated Project Times			Total Estimated Costs[4] ($)
			Treatment[2] (hours)	Logistics[3] (hours)	Total (hours)	
Move-in; move-out[5] (Low Boy expenses)	Excavator	80	5	-	5	400
	D-5 tractor	80	5	-	5	400
	Grader[7]	80	5	-	5	400
Heavy Equipment requirements for site specific treatments	Excavator	120	242	73	315	37,800
	D-5 tractor	90	146	44	190	17,100
	Dump truck	70	28	9	37	2,590
	Water truck[6]	70	46	14	60	4,200
Heavy Equipment requirements for road drainage treatments	Excavator	120	57	17	74	8,880
	D-5 tractor	90	88	26	114	10,260
	Grader[7]	80	29	9	38	3,040
	Water truck[6]	70	28	8	36	2,520
Laborers[8]		35	254	76	330	11,550
Rock Costs: (includes trucking for 1,242 yds³ of road rock and 420 yds³ of rip-rap sized rock)						49,860
Culvert materials costs (730' of 18", 1,180' of 24", 90' of 30", 70' of 36", 40' of 42", 80' of 48", 40' of 54", 50' of 60", and 150" 72"; Costs included for couplers and elbows)						43,667
Mulch, seed and planting materials for 0.47 acres of disturbed ground[9]						988
Layout, Coordination, Supervision, and Reporting[10]		--	--	--	--	29,050
Total Estimated Costs						**$222,705**

Potential sediment savings: 13,675 yds³

Overall project cost-effectiveness: $16.29 spent per cubic yard saved

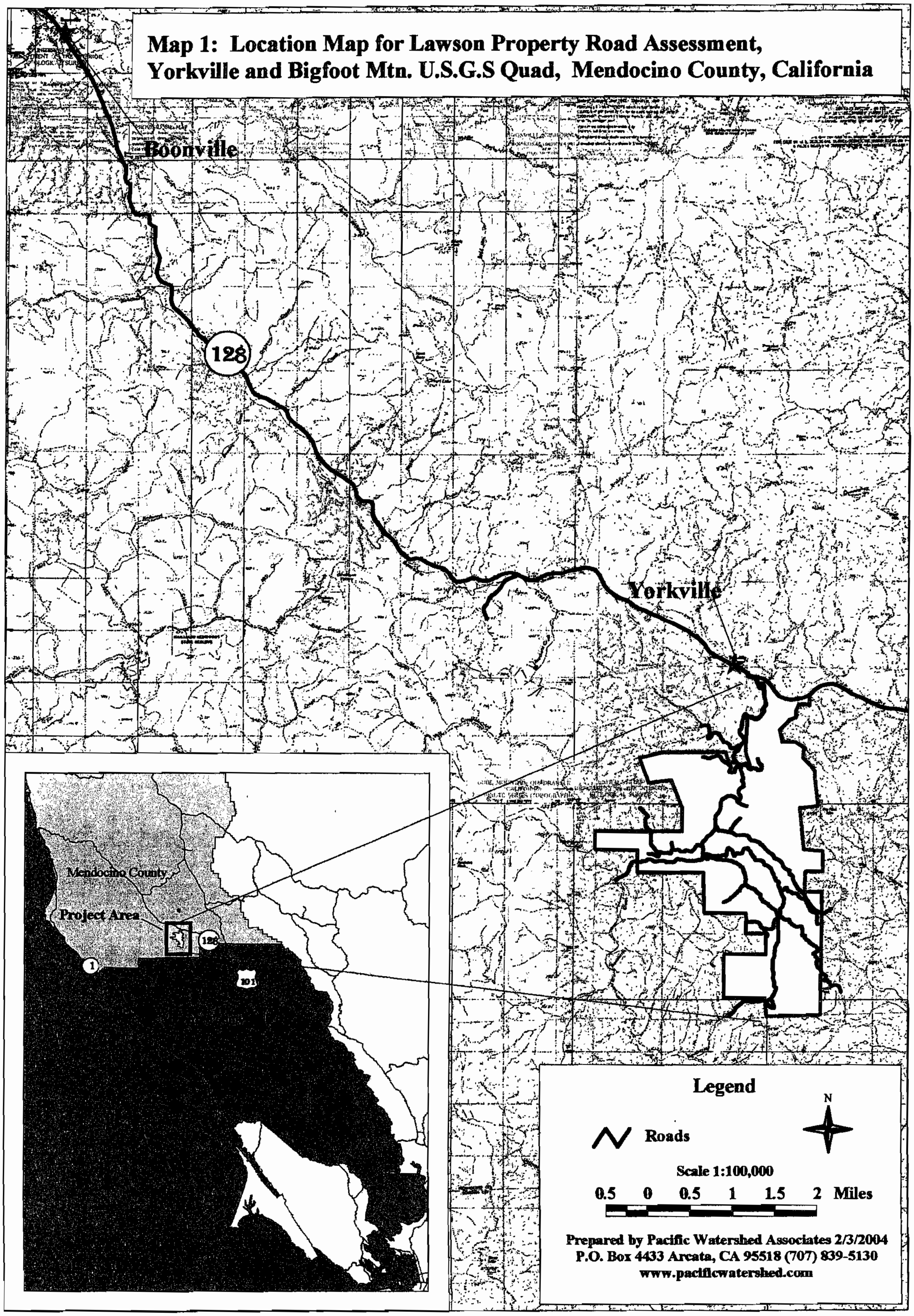
[1] Costs listed for heavy equipment include operator and fuel. Costs listed are estimates for favorable local private sector equipment rental and labor rates.
[2] Treatment times include all equipment hours expended on excavations and work directly associated with erosion prevention and erosion control at all the sites.
[3] Logistic times for heavy equipment (30%) include all equipment hours expended for opening access to sites on maintained and abandoned roads, travel time for equipment to move from site-to-site, and conference times with equipment operators at each site to convey treatment prescriptions and strategies. Logistic times for laborers (30%) includes estimated daily travel time to project area.
[4] Total estimated project costs listed are averages based on private sector equipment rental and labor rates.
[5] Lowboy hauling for tractor and excavator, approximately 2 hours round trip for two (2) crews to work areas on the Lawson road assessment area. Costs assume 2 hauls each for two pieces of equipment over the time of the project.
[6] Water truck hours include 1hour during backfill of stream crossing culvert installations and replacements and 1/4 hour for each rolling dip.
[7] An additional 11 hours of grader time is added to outslope and resurface roads post-treatment.
[8] An additional 8 hours of labor time is added for straw mulch and seeding activities.
[9] Seed costs equal $10.38/pound for native seed. Seed costs based on 50 lbs. of native seed per acre. Straw costs include 50 bales required per acre at $5 per bale. Sixteen hours of labor are required per acre of straw mulching.
[10] Supervision time includes detailed layout (flagging, etc) prior to equipment arrival, training of equipment operators, supervision during equipment operations, supervision of labor work and post-project documentation and reporting.

total equipment costs as shown in Table 5. The estimate includes costs for seed and mulch, rock armor, culvert materials, downspouts, filter fabric, as well as rock necessary for rip-rap and road surfacing at rolling dips and other specific locations.

The costs in Table 5 are based on a number of assumptions and estimates, and many of these are included as footnotes to the table. The costs provided are assumed reasonable if work is performed by outside contractors, with no added overhead for contract administration and pre- and post-project surveying. Movement of equipment to and from the site will require the use of low-boy trucks. The majority of treatments listed in this plan are not complex or difficult for equipment operators experienced in road upgrading operations on forest lands. The use of inexperienced operators would require additional technical oversight and supervision in the field. All recommended treatments conform to guidelines described in "The Handbook for Forest and Ranch Roads" prepared by PWA (1994) for the California Department of Forestry, Natural Resources Conservation Service and the Mendocino County Resource Conservation District. Costs in Table 5 assume that the work in the watershed will be accomplished during one summers work period using one equipment team. Table 5 lists approximately $29,050 for "supervision" time for detailed pre-work layout, project planning (coordinating and securing equipment and obtaining plant and mulch materials), on-site equipment operator instruction and supervision, establishing effectiveness monitoring measures, and post-project cost effectiveness analysis and reporting.

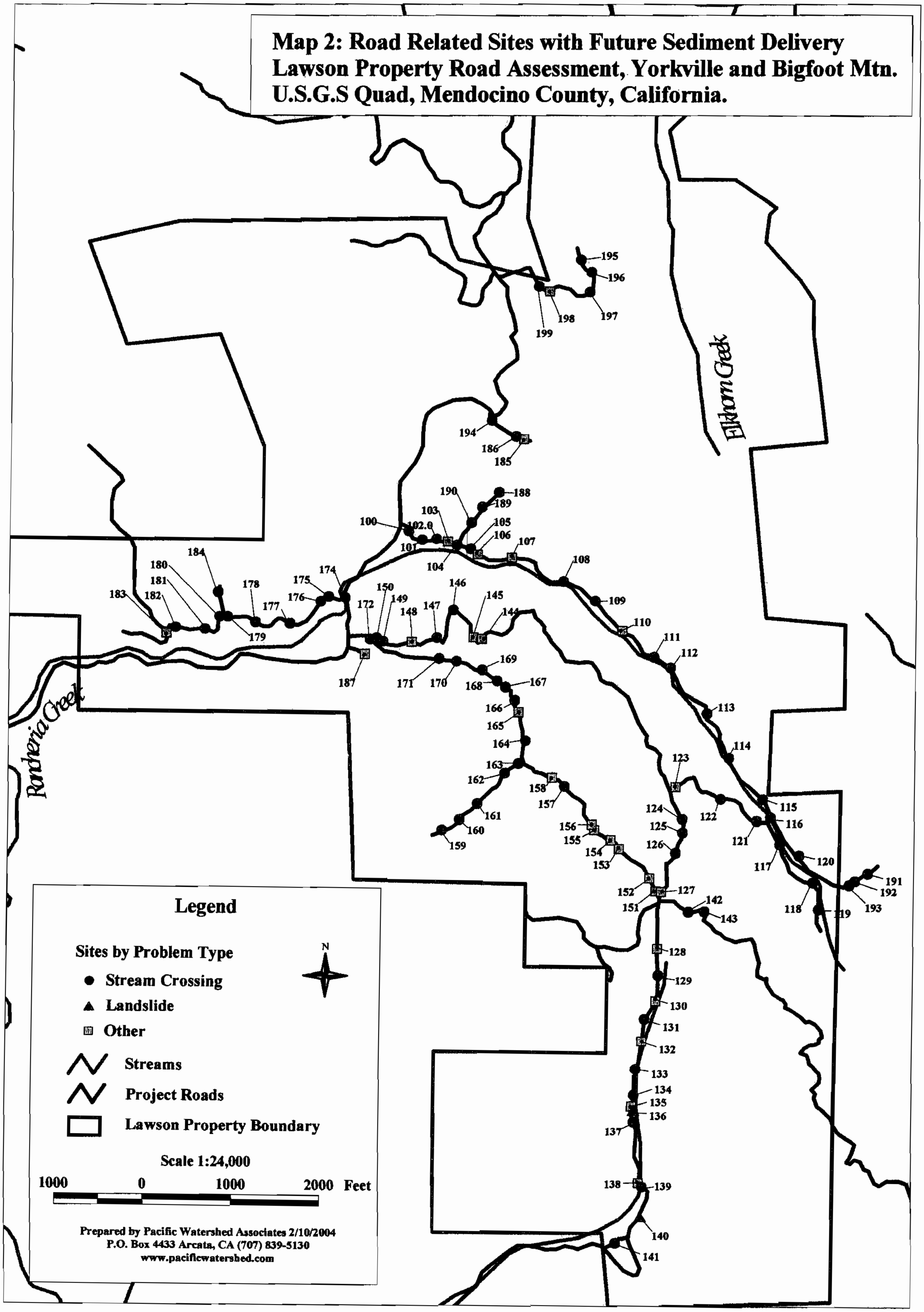
Conclusion

The expected benefit of completing the erosion control and erosion prevention planning work lies in the reduction of long term sediment delivery to Upper Rancheria Creek and its tributaries, an important salmonid stream system. For this assessment, 11.8 miles of roads on the Lawson property were considered for upgrading. Road upgrading consists of a variety of techniques employed to "storm-proof" a road and prevent unnecessary future erosion and sedimentation. Storm-proofing typically consists of stabilizing slopes and upgrading drainage structures so that the road is capable of withstanding both annual winter rainfall and runoff, as well as a large storm event without failing or delivering excessive sediment to the stream system. The goal of road upgrading is to strictly minimize the chronic contributions of fine sediment from the road bed, cutbanks and ditches in the Lawson Road assessment area, as well as to minimize the risk of serious erosion and sediment yield when large magnitude, infrequent storms and floods occur.

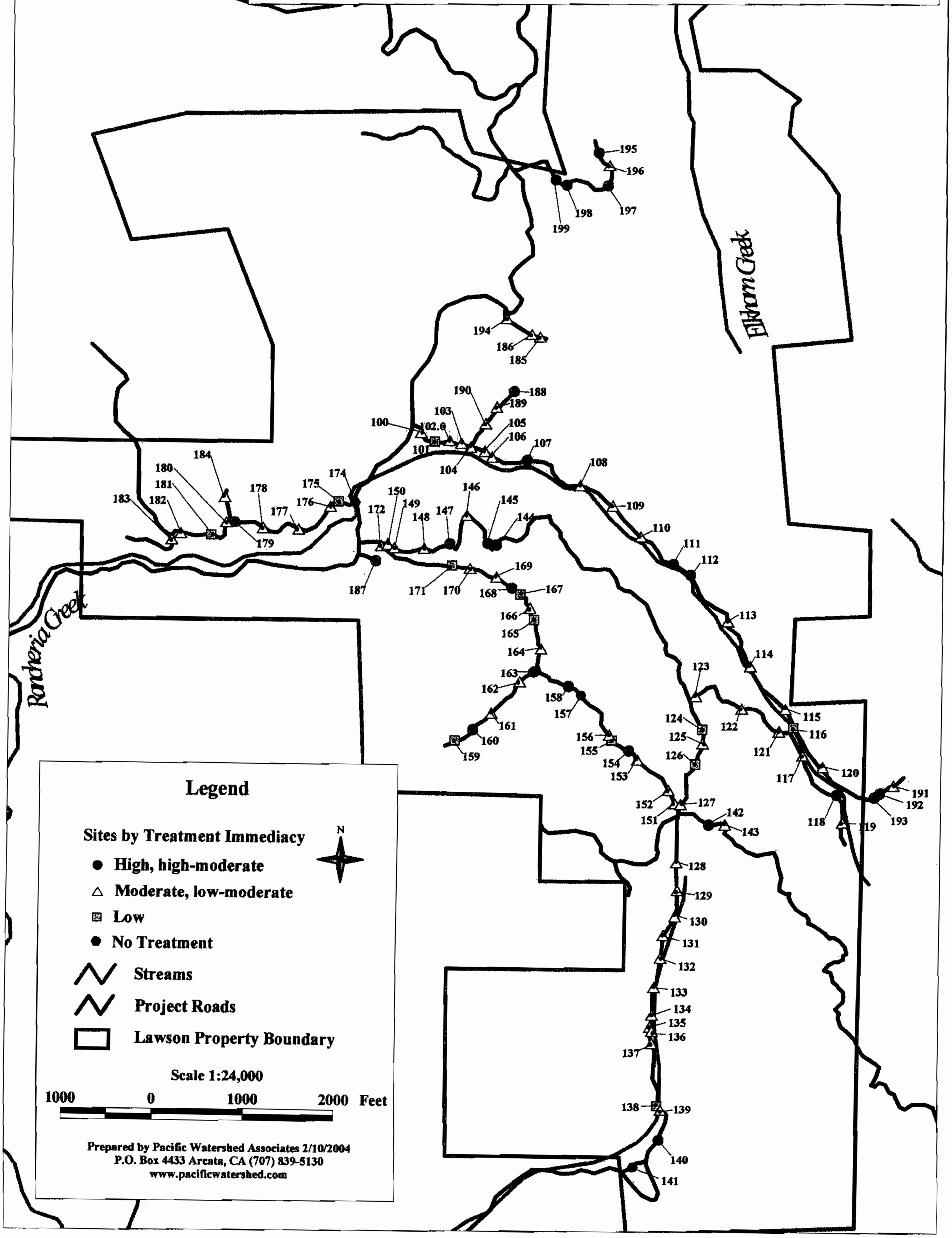


Map 1: Location Map for Lawson Property Road Assessment, Yorkville and Bigfoot Mtn. U.S.G.S Quad, Mendocino County, California
Boonville
128
Yorkville
Mendocino County
Project Area
128
1
101
Legend
Roads
N
Scale 1:100,000
0.5 0 0.5 1 1.5 2 Miles
Prepared by Pacific Watershed Associates 2/3/2004
P.O. Box 4433 Arcata, CA 95518 (707) 839-5130
www.pacificwatershed.com

Map 2: Road Related Sites with Future Sediment Delivery
Lawson Property Road Assessment, Yorkville and Bigfoot Mtn. U.S.G.S Quad, Mendocino County, California.



Map 3: Treatment Immediacy for Road Related Sites, Lawson Property Road Assessment, Yorkville and Bigfoot Mtn. U.S.G.S Quad, Mendocino County, California.



Appendix A

Road Erosion Inventory Data Form Used for the Lawson Road Assessment

ASAP ___ ***PWA* ROAD INVENTORY DATA FORM** (9/02 version) CHECK_____

NERAL	Site No:______	Watershed:	Subwatershed:	CALWAA:	Sketch (Y, N)		
Treat (Y,N):	Photo:________	Road #:	Mileage:___________	Landowner:			
GPS:	Inspectors:_________	Date:_______	Year Built:______	Surface - rocked, native, paved, chip seal (R, N, P, C):________			
	Maintained	Abandoned	Decomissioned	Driveable, quad, walk (D,Q,W):_______	Upgrade	Decomission	Maintenance
PROBLEM	Stream xing	Landslide	Roadbed (bed, ditch, cut)	DR-CMP	Gully	Channel scour	Bank erosion
	Spring	Other					
	Location of problem (U, M, L, S)	Road related? (Y, N)	Harvest Type (CC, TC, PC, PT, ASG, No)	Harvest age- 1=<15 yrs, 2=>15 -30 yrs, 3=>30 yrs	Geomorphic Association: SS, IG, ST, SW, HD, BIS, Other		
ROAD/ DITCH INFO	Left road/ditch length (ft):	Right road/ditch length (ft):	Left rd grade%:	Right rd grade%:			
LANDSLIDE	Road fill	Landing fill	Cutbank slide	Hillslope debris slide (>50% original ground)	Deep seated, slow landslide	Past failure	Potential failure
	Slope shape: (convergent, divergent, planar, hummocky)	Natural slope %:___________	Distance from toe to stream (ft):_______				
STREAM	CMP	Bridge	Humboldt	Fill	Ford	Armored Fill	Pulled crossing
	% pulled:_____						
	% washed out: ___	CMP diam (in):	Culvert type (P, S, A, C)	Inlet (O, C, P, R)	Outlet (O, C, P, R)	Bottom (O, C, P, R)	Separated (Y, N)
	Plug potential (H, M, L)	Headwall (in)_____	CMP slope % _____	Rust/silt line (in):_____	CMP appears undersized (Y, M, N):____		
	Stream class (1, 2, 3)	Sed trans (H,M,L)	Ch grade (%)_____	Ch width (ft): _______	Ch depth (ft):_______		
	Diversion Pot?(Y, N):	Currently dvted? (Y, N)	Past dvted? (Y, N)				
	Pool dimension (ft) - NOW - width____ depth____	Pool dimension (ft) - B.F. - width____ depth____	Fish-outlet drop (ft) - now:____ at bankful:____				
EROSION	E.P. (H, M, L)	Potential for extreme erosion? (Y, N)	Volume of extreme erosion (yds^3): <500, 500-1000, 1-2K, 2-5K, >5K				
Past Erosion..	Total Past Erosion (yds^3):	Past delivery %:	Total Past Yield (yds^3):	Age of past erosion (decade):			
ture Erosion..	Total Future Erosion (yds^3):	Future delivery %:	Total Future Yield (yds^3):				
	Future width (ft):	Future depth (ft):	Future length (ft):				
TREATMENT	Immed (H, M, L)	Complexity (H,M,L):	Mulch (ft^2):				
	Excavate soil	Critical dip	Wet crossing (ford or armored fill) (circle)	armored fill hgt (ft)______	armored fill/ford width (ft) _______		
	Armor size range (ft):	Armor vol (yds^3) :	Trash Rack	Downspout diam (in):_______	D.S. length (ft) ________		
	Repair CMP	Clean CMP	Install bridge	Install culvert	Replace culvert	CMP diameter (in) _____	CMP length (ft) _______
	Road bed post exc.: (lower, raise, same elevation)	Lower/raise (ft):	Road alignment post exc. (move in, out, same location)	Move in/out (ft):			
	Install flared inlet	Flared inlet diam (in):	Reconstruct fill	Armor fill face (up, down)	Armor area (ft^2) :		
	Armor size range (ft) :	Armor vol (yds^3) :	*Clean or cut ditch length (ft)* ________	*Outslope & Retain ditch (ft)* ______			
	Outslope & Remove ditch (ft) _______	*Inslope road (ft)* ___________	*Remove berm (ft)* __________				
	Remove ditch (ft) _________	*Rock road- ft^2* ______	*Rolling dip (#)* ___				
	Install DR-CMP (#) ___	*Install DR-CMP diam (in):*	*Install DR-CMP length (ft):*	*Replace DR-CMP (#)* ___	*Replace DR-CMP diam (in):*	*Replace DR-CMP length (ft):*	
	Cross rd. drain (#) ___	*Decommission outsloping length (ft):*	Check CMP	Other tmt? (Y)			

COMMENT ON PROBLEM:

EXCAVATION VOLUME	Total excavated (yds³) _______	Vol put back in (yds³) _______	Volume removed (yds³) _______	
	Vol stockpiled (yds³) _______	Vol endhauled (yds³) _______	Dist endhauled (ft) _______	Excav prod rate (yds³/hr) _______
EQUIPMENT HOURS	Excavator (hrs) _______	Dozer (hrs) _______	Dump truck (hrs) _______	Grader (hrs) _______
	Loader (hrs) _______	Backhoe (hrs) _______	Labor (hrs) _______	Other (hrs) _______

COMMENT ON TREATMENT:

Stream Profile Through Crossing (begin at top of profile)	*Xing type 1, 2, 3, 4* (Circle)		
Angle (deg) (dwn=-)	Distance (feet)	Code (**UES, TOP, IBR, OBR, BOT XS1, XS2...,LES**)	Comment
0	0	UES, TRN	in natural channel

Cross Section(s) (begin on left bank)				
xs#	Angle (deg)	Distance (feet)	Code (**LRP, LEC, CLP, REC, RRP**)	Comment
1	0	0	LRP, TRN	Base of cutbank

Computer volumes-

1. Computer erosion volume (1:1): ___________
2. Culvert excavation vol (add/repl - 1:1): ___________
3. Humboldt excavation volume (1:1): ___________
4. Decommission volume (2:1): ___________

Site Sketch - Site No.______

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consideration. Both creeks had an average maximum pool depth of only 1.5 feet; optimal pool depth is at least 2 ft in 1st and 2nd order channels and greater than 3 ft in 3rd and higher order channels. Bear Wallow has a 5.5% slope and Beasley has a 3-4% slope. In the entire watershed, coho were only present in streams with gradients less than 2% and steelhead were present in streams with gradients less than 8% (Entrix 1998). Stream gradient is likely a limiting factor for coho in both creeks. In terms of canopy cover, both creeks are adequate. Bear Wallow Creek has high to moderate cover except where land slides have occurred and Beasley Creek had cover greater than 65% which was composed mostly of deciduous trees and hardwoods.

Streams draining the north slopes of upper Rancheria Creek including Maple, Shearing, and Beebe Creeks are located in Franciscan melange-grassland terrain, with relatively small, steep subbasins, and limited LWD input. These streams are not suitable for coho habitat and likely only provide marginal steelhead habitat. Lower Rancheria Creek tributaries on the southwest side of the basin located within forested Franciscan Coastal Belt terrain include Dago, Cold Springs, Minnie, Horse Camp, and Beasley Creeks. It is probable that these streams provide suitable stream temperatures and potential for LWD recruitment to enhance and expand salmonid habitat.

Adams and Yale Creek, which are located in the upper watershed, historically provided habitat for only steelhead. There is recent evidence of coho only in Dago Creek in the Lower Rancheria Creek subbasin. Although Cold Springs, Minnie, and Camp Creeks were not field checked, they are thought to be similar to Dago Creek (Entrix 1998).

Invasive plant species
The Navarro River watershed contains over 1000 species of plants in natural habitats. Of these, about 20% are non-native (Montgomery, undated). Many non-native plants naturalize without causing perceptible harm to the system; however, some non-native plants possess both the potential to disrupt the structure and function of native ecosystems and the ability to rapidly expand their range and population size in their new habitat. These plants may pose a serious threat to native plant and animal communities by out-competing native vegetation, altering fire regimes, interrupting successional processes, consuming a disproportionate amount of groundwater, or otherwise interfering with ecosystem processes. Additionally, invasive non-native plants have socioeconomic costs associated with prevention, control, and mitigation, as well as indirect costs associated with impacts to ecological services.

Fifteen non-native invasive plants that have the potential to negatively impact the Navarro River watershed were identified by local natural resource organizations. These plants and some of their characteristics are presented in Table 2.

Table 2. Non-native Invasive Plant Management

Common Name	Scientific Name	Reproduction	Habitat Preference	Control Methods
Tree-of-heaven	*Ailanthus altissima*	Seed, stump and root sprouts	Disturbed areas, prefers dry	Manual, mechanical, chemical

			soil	
Giant reed	*Arundo donax*	Rhizomes	Well-drained soils with abundant moisture	Manual, mechanical, chemical, grazing
Yellow starthistle	*Centaurea solstitialis*	Seed	Open grasslands with deep well-drained soils	Mechanical, grazing, burning, biological, chemical
Poison hemlock	*Conium maculatum*	Seed	Wet soils	Manual, mechanical, chemical
Jubata grass	*Cortaderia jubata*	Seed, fragmented tillers	Disturbed coastal areas, estuaries, grasslands, wetlands	Manual, mechanical, chemical
Scotch broom	*Cytisus scoparius*	Seed, resprouts	Disturbed areas, grassland, shrubland, and open canopy forest	Manual, mechanical, burning, chemical
English ivy	*Hedera helix*	Seeds, tillers	Open forests	Manual, mechanical, burning, chemical (on young plants)
Klamathweed	*Hypericum perforatum*	Seeds, rhizomes	Grasslands, open forest, disturbed areas	Manual, mechanical, biological
Pennyroyal	*Mentha pulegium*	Seed, stolons	Moist meadows, marshes, ditches, disturbed sites	Chemical
Himalayan blackberry	*Rubus discolor*	Seeds, clonal	Disturbed sites, moist	Manual, mechanical,

			areas	chemical, burning
Sheep sorrel	*Rumex acetosella*	Seeds, root resprouts	Grasslands, disturbed areas	Manual, mechanical, chemical
Tansy ragwort	*Senecio jacobaea*	Seeds, root resprouts	Disturbed areas, stream banks, grasslands, open forests	
Milk thistle	*Silybum marianum*	Seeds	Disturbed sites with fertile soil	Manual, mechanical, chemical
Common spring vetch	*Vicia sativa*	Seeds	Disturbed sites	Manual, mechanical, chemical
Periwinkle	*Vinca major*	Rhizomes	Moist shaded areas, riparian banks	Manual, mechanical, herbicide

Non-native Animal Species

The presence of non-native animal species can alter plant and animal species composition, disrupt ecosystem processes, and influence geomorphic regimes such as sediment transport. Wild turkey (*Meleagris gallopavo*), wild pig (*Sus scrofa*), Virginia opossum (*Didelphis virginiana*), feral cat (*Felis catus*), and bullfrog (*Rana catesbiana*), are important non-native animal species that are likely to occur in the Rancheria Creek subwatershed.

Turkeys are considered a valuable upland game bird by CDFG. They prefer open woodland habitat and have an omnivorous diet, consisting of other bird eggs, acorns, seeds, small insects, wild berries, and small reptiles. During foraging, they cause soil disturbance and they may outcompete other wildlife seeking similar food or habitat. Wild pigs occur in nearly every habitat type in California, although they prefer woodland, chaparral, grasslands, and wetlands. They are omnivorous, consuming herbs in spring, mast and fruit during summer and fall, and roots, tubers, and invertebrates year-round. Wild pigs are considered a potential competitor for food with deer, bear, rodents, raccoons, and waterfowl. While rooting, they can change species composition and successional patterns and alter nutrient cycling. Additionally, they can hamper the regeneration of woody species by consuming acorns and seedlings and increase sedimentation in streams by rooting and wallowing. Virginia opossum occur in a wide range of habitats but are most common in urban and suburban settings. They may compete for food and shelter with other mammals such as skunk, fox, weasels, and

NORTH COAST INTEGRATED REGIONAL WATER MANAGEMENT PLAN

North Coast Integrated Regional Water Management Plan
Proposition 84 Round 1 Implementation Grant

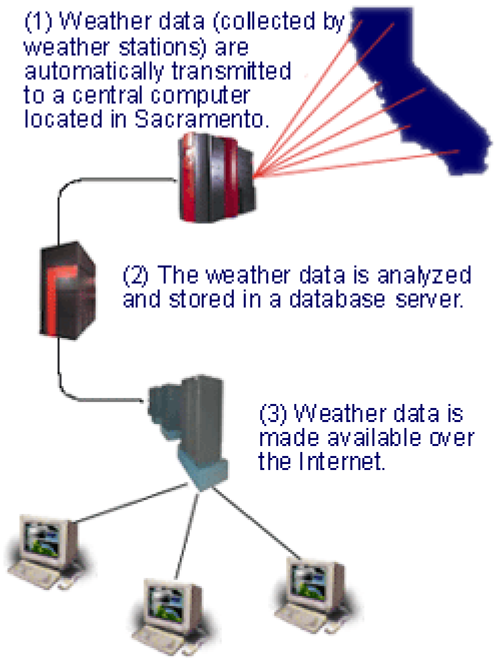
Priority Project Technical Documents: Plans and Specifications

355 - Real-Time Weather Data for Irrigation Water Management, Del Norte Resource Conservation District

- CIMIS Weather Station Overview, Siting Info, Spensor Specs

CIMIS Overview

The California Irrigation Management Information System (CIMIS) is a program of the Office of Water Use Efficiency (OWUE), California Department of Water Resources (DWR) that manages a network of over 120 automated weather stations in the state of California. CIMIS was developed in 1982 by DWR and the University of California, Davis to assist irrigators in managing their water resources efficiently. Efficient use of water resources benefits Californians by saving water, energy, and money.



Data Collection and Transmission

CIMIS weather stations collect weather data on a minute-by-minute basis, calculate hourly and daily values and store them in the dataloggers. A computer at the DWR headquarters in Sacramento calls every station starting at midnight Pacific Standard Time (PST) and retrieves each day's data.

In case of a communication problem between the central computer and a given station, the computer skips that station and calls the next station. After all other stations have reported the polling computer comes back to the station with a communication problem trying to establish a connection at predetermined time intervals. The interrogation continues into the next day until all of the station data have been transmitted.

Data Processing

Once the data is transmitted, the central computer analyzes it for quality, calculates reference evapotranspiration (ETo - for grass reference and ETr - for alfalfa) and other intermediate parameters, flags the data (if necessary), and stores them in the CIMIS database. Evapotranspiration (ET) is a loss of water to the atmosphere by the combined processes of evaporation from soil and plant surfaces and transpiration from plants. Reference evapotranspiration is the loss of water from standardized grass or alfalfa surfaces over which the stations are sitting. Irrigators have to use crop factors, known as crop coefficients, to convert ETo/ETr into an actual evapotranspiration (ETc) by a specific plant.

Since most of the CIMIS stations are sitting on standardized grass surfaces, reference evapotranspiration is commonly referred to as "ETo" in this web site. However, it is worth mentioning that a few CIMIS stations are sited on standardized alfalfa surfaces and therefore evapotranspiration from such surfaces is referred to as ETr.

Data Retrieval

Estimated parameters (such as ETo, net radiation (Rn), dew point temperature, etc.) and measured parameters (such as solar radiation (Rs), air temperature (T), relative humidity (RH), wind speed (u), etc.) are stored in the CIMIS database for unlimited free access by registered CIMIS data users. In the past, users were accessing the CIMIS database via the dial-up and telnet systems. CIMIS then developed an older version of its current web site, during which time users were able to access the database using the dial-up, telnet, and/or the web systems. Once the web site became fully functional, the dialup and telnet options were terminated. Currently, the web system is the only platform for retrieving the CIMIS data. In addition to the web, CIMIS developed an ftp site for those interested in automated access of the data. However, the ftp site only provides daily data for the previous 7 days and monthly data for the previous 12 months. Also available at the ftp site is one year's worth of rolling daily ETo data. This means that the beginning and ending dates of this data advance forward by one day everyday.

Selecting Representative Stations

The CIMIS weather stations are randomly distributed throughout the State of California. It is very important that the selected station represents the same microclimate as the area of interest. Some resources available to assist you in this regard include the CIMIS web site, local water districts, farm advisors, consultants, and CIMIS staff.

Contact information for CIMIS staff at the Sacramento headquarters and the DWR districts are provided in the CIMIS Staff link on the Home Page. Questions regarding the selection of a CIMIS station, installation of new station, missing data, and/or information on how to use the data can be directed to the CIMIS staff in your DWR district. There are four DWR districts in California. To find out in which district your County lies, click here, for district location maps. If you have problems contacting the CIMIS staff in your district, you can Contact Us at headquarters in Sacramento.

Trends in CIMIS Data Users

Although CIMIS was initially designed to help agricultural growers and turf managers administering parks, golf courses and other landscapes to develop water budgets for determining when to irrigate and how much water to apply, the user base has expanded over the years. In addition to those mentioned above, current CIMIS data users include local water agencies, fire fighters, air control board, pest control managers, university researchers, school teachers and students, construction engineers, consultants, hydrologists, state and federal agencies, utilities, lawyers, weather agencies, and many more.

The number of registered CIMIS data users has also been growing steadily over the years. Currently, there are over 6000 registered CIMIS data users. It is worth mentioning here that this number reflects only those that are primary users of the CIMIS data. It has been established that many users get the CIMIS data from these primary users for various uses. Examples include local water districts and consultants providing the CIMIS data to their clients. Therefore, there are secondary and tertiary CIMIS data users that have not been accounted for by the figure presented here.

Sensor Specs

The following sensor specifications, (except sensor heights, are provided by the particular sensor manufacturer):

1. Total solar radiation (pyranometer)
2. Soil temperature (thermistor)
3. Air temperature/relative humidity (HMP35)
4. Wind direction (wind vane)
5. Wind speed (anemometer)
6. Precipitation (tipping-bucket rain gauge)

1. Total solar radiation (pyranometer)

Sensor:	Pyranometer--high stability silicon photovoltaic detector (blue enhanced)
Model:	LI200S
Maker:	Li-Cor
Height:	10K ohm potentiometer vane
Sensitivity:	±5% error under natural sunlight conditions. Typically 80 micro Ampere per 1000 watts per square meter.
Linearity:	Maximum deviation of 1% up to 3000 watts per square meter.
Response time:	10 micro seconds.
Correction:	Cosine corrected up to 80 degrees angle of incidence.
Azimuth:	±1% error over 360 degrees at 45 degrees elevation

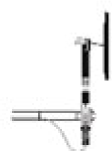
2. Soil temperature (thermistor)

Sensor:	Soil Thermistor--Fenwal Electronic UUT51J1 thermistor in water resistant coating.
Model:	107b
Maker:	Fenwal/ modified by Campbell Scientific Inc.
Height:	15 cm (6 in) below soil surface under irrigated grass.
Accuracy:	Worst case ±0.4 degrees C over -33 to 48 degrees C, ±0.5 degrees C at -40 degrees C

3. Air temperature/relative humidity (HMP35)

Sensor:	Fenwall Thermistor/HUMICAP H-sensor
Model:	HMP35C
Maker:	Vaisala/modified by Campbell Scientific, Inc.
Height:	1.5 m
Range	0 to 100% RH, -35 to +50 degrees C
Accuracy:	±2% RH (0-90% RH), ±5% RH (90-100%), ±0.1 °C over -24 to 48 °C range
Note:	Both sensors are enclosed in a 12-plate naturally aspirated radiation shield made by R. M. Young.

4. Wind direction (wind vane)



Sensor:	2.0 meters
Model:	024A
Maker:	Met-One
Height:	2.0 meters
Range:	0-360 degrees
Output:	0-10 * 10^3 Ohms
Threshold:	0.45 m per sec (1 mph)
Accuracy:	±5%
Delay distance:	less than 1.3 m

5. Wind speed (anemometer)

Sensor:	Three-cup anemometer utilizing a magnet activated reed switch whose frequency is proportional to wind speed
Model:	014A
Maker:	Met-One
Height:	2.0 meters
Range:	0-45 m per sec (0-100 mph)
Threshold:	0.45 m per sec (1 mph)
Gust Survival:	0-53 m per sec (0-120 mph)
Accuracy:	1.5% or 0.11 m per sec (0.25 mph)

6. Precipitation (tipping-bucket rain gauge)

Sensor:	Tipping-bucket rain gauge with magnetic reed switch.
Model:	TE525MM
Maker:	Texas Electronics
Height:	1.0 meters
Orifice:	24.5 cm (9.644 in)
Resolution:	0.1 mm
Accuracy:	±1% at 5 cm per hr or less.

Siting Info

The placement of a weather station and the local environment of a weather station site can affect the utility and accuracy of ETo (calculated using the stations' weather data) for the area in which it is located. Buildings or trees close enough to a weather station can affect wind speed data, which in turn affects the resultant calculated ETo. The absence of a healthy green grass under a weather station can affect net radiation severely and humidity to some degree, which will adversely affect ETo. Bare soil instead of cropped land around the weather station can increase advected energy, increasing temperatures and decreasing humidities, which would increase the ETo value.

A CIMIS weather station should be located within the area that the station is meant to represent. The overriding factor in locating any CIMIS weather station is that the station location should be representative of the largest possible surrounding area. This will insure the most efficient use of weather stations for supplying accurate and applicable ETo information. The ideal site for a CIMIS weather station would be located in a 20-acre or larger pasture that is well maintained. The actual weather station would be located in the center of the pasture, inside a 10-yard to by 10-yard fenced enclosure. Inside the enclosure, the grass would also be well maintained (properly irrigated and fertilized) and mowed frequently to maintain a height between three to six inches.

It is often very difficult to find such a site for a new weather station. In some areas, there are few pastures. Also, if a pasture is found, the landowner must agree on allowing a weather station to be sited there. DWR has prepared, with the help of UC, the following criteria or guidelines to be used to find and judge sites for CIMIS weather stations when an ideal pasture cannot be found.

Regional and Local Criteria

1. A station should be sited within the region it is meant to represent.
2. Avoid locating a station in a transition area between two regions of distinct climates unless you are attempting to characterize that transitional area.
3. Topographic depressions should be avoided, as the temperature is frequently higher during the day and lower at night. High points should also be avoided in most cases.
4. There should be a long-term commitment to maintain the same land use in and around the site, to avoid moving the station in the future.

Surrounding Environment Criteria

1. Avoid wind obstructions within 100 yards of the site. Avoid linear obstructions (windbreaks, buildings) within 150 yards perpendicular to the direction of the prevailing wind.
2. Avoid placing a station in a field where there are frequent rotations of crops, because between crops the field will have bare soils.
3. Avoid abrupt crop/vegetation changes (i.e. pasture to row crops) within 50 yards of site, or 100 yards upwind of site.
4. Avoid roads within 50 yards of the site. Unpaved roads should be no closer than 100 yards upwind of the site.
5. Small rivers should be no closer than 100 yards of the site and larger rivers should be no closer than 200 yards of the site. Lakes should be no closer than 1,000 yards of the site.
6. Avoid areas exposed to extensive or frequent applications of agricultural chemicals (can cause increasing degradation of sensors).

Other General / Desirable Criteria

1. Site should have nearby dwellings (no closer than 100 yards) to reduce risk of vandalism.
2. The station enclosure should be a 10-yard by 10-yard by five-foot high fence, livestock-tight where necessary. The posts, boards and fencing material should not affect wind nor shade any instruments.
3. Site should have unrestricted access, seven days a week. There should be vehicle access to the site enclosure (except when wet).
4. Site should be close to existing telephone lines (within 150 yards) for economical connections.
5. There should be local personnel (private or public) to help maintain the site to meet DWR's requirements.

Many of the weather stations sites in the CIMIS network are not the ideal large pasture situation. Some of these stations do not meet all of the above siting criteria. These sites will be upgraded if possible or relocated to a better quality site in the future. Specific information on each CIMIS site can be obtained by clicking on "Station List" and then the station number.

North Coast Integrated Regional Water Management Plan
Proposition 84 Round 1 Implementation Grant

Priority Project Technical Documents: Plans and Specifications

441 - Waterfall Gulch Transmission Main, City of Fort Bragg

- Waterfall Gulch Transmission Main State Highway 20 to Brush Creek Road Plans and Technical Specifications

IMPROVEMENT PLANS FOR

WATERFALL GULCH TRANSMISSION MAIN

STATE HIGHWAY 20 TO BRUSH CREEK ROAD

CITY OF FORT BRAGG
MENDOCINO COUNTY, CALIFORNIA

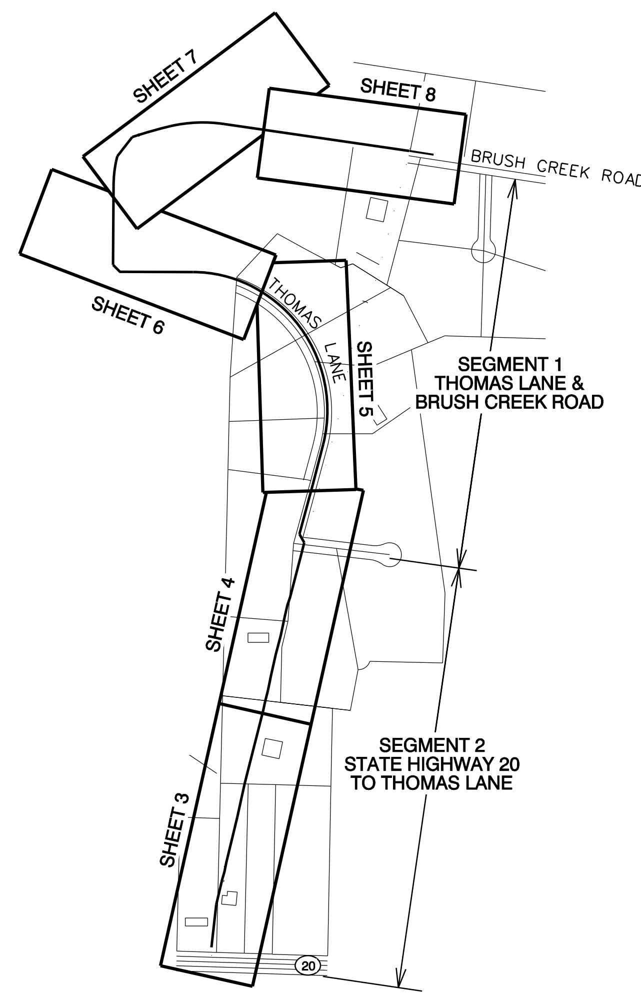
WDID # _____________

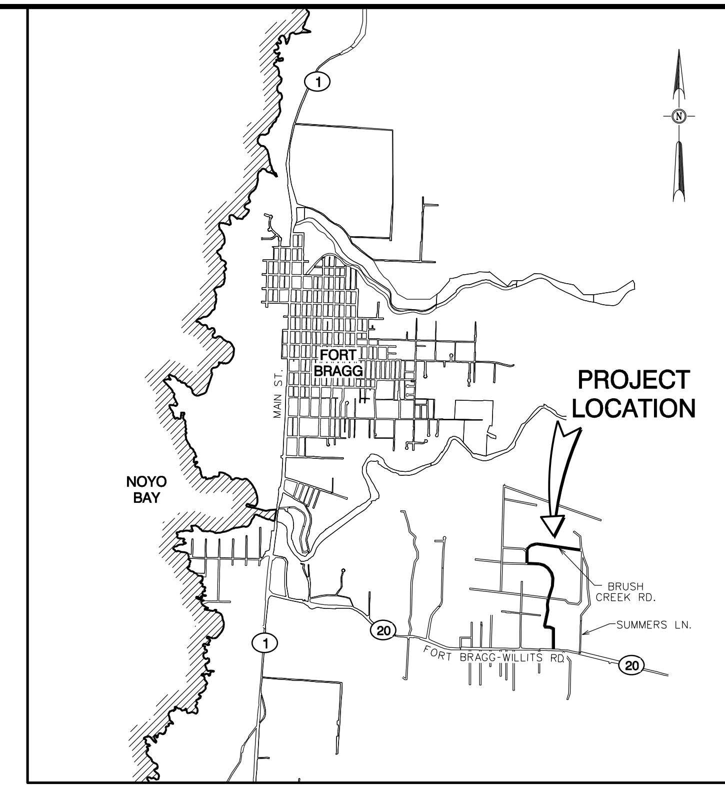
LEGEND

EXISTING	PROPOSED	
8"	10"	DOMESTIC PIPELINE WITH SIZE
		GATE VALVE
		BUTTERFLY VALVE
8" 6"	8" 6"	REDUCER
		CHECK VALVE
4"	4"	PRESSURE REDUCER VALVE WITH SIZE
A	A	ALTITUDE VALVE
4"	4"	PRESSURE RELIEF VALVE WITH SIZE
		SERVICE LATERAL
	2"	AIR/VACUUM RELEASE VALVE W/SIZE
		FIRE HYDRANT
12" SD	12"SD	STORM DRAIN
10"SS	6"SS	SANITARY SEWER
E (U.G.)	E (U.G.)	ELECTRICAL (UNDERGROUND)
E (O.H.)	E (O.H.)	ELECTRICAL & POLE (OVERHEAD)
T (U.G.)	T (U.G.)	TELEPHONE (UNDERGROUND)
T (O.H.)	T (O.H.)	TELEPHONE & POLE (OVERHEAD)
G	G	GAS LINE
56	56	CONTOUR
		TREE
		POINT OF CONNECTION
	7 / 11	DENOTES DETAIL NUMBER DENOTES SHEET NO. WHERE DETAIL IS DRAWN. WHEN CALLED OUT IN NOTES, SHOWN AS DETAIL (7/11)
		BLIND FLANGE

SHEET KEY MAP

1" = 400'





VICINITY MAP

NO SCALE

INDEX OF SHEETS

CITY OF FORT BRAGG

APPROVED BY: ____________ DATE ______

PROJECT REPRESENTATIVES

AGENCY	REPRESENTATIVES	PHONE
CITY PUBLIC WORKS DIRECTOR	DAVE GOBLE	(707) 961-2823
PROJECT ENGINEER	KASL CONSULTING ENGINEERS	(916) 722-1800
CITY PUBLIC WORKS SUPERINTENDENT	MIKE CIMOLINO	(707) 961-2841
U.S.A. NORTH		(800) 642-2444

REVISIONS

NO.	DESCRIPTION	DATE	BY

BENCHMARK
FORT BRAGG DATUM

ELEV. ______
DATUM: NAVD 88

RELEASE 4
OCT. 2010

SCALE: NONE
JOB NO. 2719-02

REGISTERED PROFESSIONAL ENGINEER
JOHN C. SCROGGS
No. 26388
Exp. 3-31-12
CIVIL
STATE OF CALIFORNIA

IMPROVEMENT PLANS FOR CONSTRUCTION OF
WATERFALL GULCH TRANSMISSION MAIN
STATE HIGHWAY 20 TO BRUSH CREEK ROAD
FORT BRAGG, CALIFORNIA

TITLE / COVER SHEET

CONSULTING
KASL
ENGINEERS
7777 Greenback Lane
Suite 104
Citrus Heights, CA 95610
Tel. (916) 722-1800
Fax (916) 722-4595
CIVIL - WATER RESOURCES - SURVEYING

CITY OF FORT BRAGG WATER MAIN CONSTRUCTION NOTES

STD. NO. 500

1. ALL MATERIAL, WORKMANSHIP, AND CONSTRUCTION DETAILS SHALL CONFORM TO THE CITY OF FORT BRAGG, "STANDARD SPECIFICATIONS," INCLUDING ALL ADDENDA, STANDARD PLAN REVISIONS AND SPECIAL PROVISIONS.

2. START EXCAVATION BY EXPOSING END OF EXISTING MAIN TO DETERMINE ITS LINE AND GRADE. START NEW MAIN 8 - 10 FEET FROM, AND ON SAME LINE AND GRADE AS EXISTING MAIN. PIPE LAYING SHALL THEN BE ADJUSTED SO THE DEPTH OF NEW MAIN CONFORMS TO NOTE #3.

3. MINIMUM DEPTH OF COVER FROM FINISHED GRADE SHALL BE: 40" FOR 10" MAINS. MAIN LINE VALVES SHALL BE RESILIENT SEAT GATE. BLOW OFF VALVES SHALL BE 2" OR 3" BALL VALVES WITH ROTATION STOPS.

4. NO. 10 INSULATED COPPER WIRE SHALL BE LAID ON TOP OF AND ALONG ENTIRE LENGTH OF ALL NONMETALLIC MAINS AND SHALL BE EXTENDED TO THE SURFACE AT ALL VALVE LOCATIONS, BLOWOFFS AND METER BOXES SUFFICIENT FOR LOCATOR EQUIPMENT TO BE ATTACHED. FASTEN THE WIRE TO THE TOP OF THE PIPE SO AS NOT TO BE DISPLACED BY BACKFILLING PROCEDURE (ONE METHOD OF ACCOMPLISHING THIS IS TO AFFIX THE WIRE TO THE TOP OF THE PIPE WITH DUCT TAPE AT APPROXIMATELY 10 FEET INTERVALS).

5. MAINS TO BE CONSTRUCTED WITHIN 10' OF SEWER PIPE REQUIRE SPECIAL INSTALLATION AND DESIGN MUST BE SPECIFICALLY APPROVED BY THE DIRECTOR OF PUBLIC WORKS.

6. ALL TRENCHING, BACKFILL AND RESURFACING REQUIRED FOR INSTALLATION OF WATER SYSTEM FACILITIES SHALL BE PER CITY STANDARD 300.

7. ONLY CITY PERSONNEL SHALL OPERATE VALVES ON EXISTING WATER MAINS OR WATER SERVICES.

8. ALL VAULTS AND PITS SHALL BE BEDDED ON 3" MINIMUM THICK, 3/4" DRAIN ROCK, AB-2, OR OTHER CLEAN MATERIAL WITH TYPICAL SAND EQUIVALENT OF 20 MINIMUM, UNCONTAMINATED BY NATIVE SOIL, AGAINST COMPACTED OR UNDISTURBED BASE. THE GRAVEL BED SHALL EXTEND TO A 4" MINIMUM BEYOND ALL SIDES OF THE METER BOX. BOX SHALL BE SET FLUSH WITH TOP OF CURB, SIDEWALK OR GROUND, WHICHEVER IS APPLICABLE. LOT NUMBERS MUST BE NOTED ON TOP SIDE OF METER BOX WITH A PERMANENT MARKING PEN.

9. ITEMS SPECIFIED ON THE STANDARD PLANS, OR THE ENGINEER'S APPROVED LIST, ARE APPROVED FOR USE BY THE DIRECTOR OF PUBLIC WORKS. ALL OTHERS SHALL BE SUBMITTED TO THE DIRECTOR OF PUBLIC WORKS FOR APPROVAL.

10. GASKETS FOR FLANGE FITTINGS SHALL CONFORM TO AWWA STD. C115.

11. UPON APPLICATION, THE CONTRACTOR SHALL INSTALL A 2" TEMPORARY CHECK VALVE ON THE END OF THE EXISTING MAIN FOR CONSTRUCTION WATER (SEE STANDARD), OR AT THE OPTION OF THE DIRECTOR OF PUBLIC WORKS. THE CONTRACTOR MAY HAVE A FIRE HYDRANT METER INSTALLED BY CITY PERSONNEL.

12. UPON COMPLETION OF CONSTRUCTION, FINAL CONNECTION WILL BE MADE BY THE CONTRACTOR UNDER INSPECTION BY A CITY REPRESENTATIVE, UNLESS OTHERWISE SPECIFIED ON THE PLANS.

13. WHEN A CONNECTION IS REQUIRED TO AN EXISTING WATER MAIN, THE CONTRACTOR SHALL PROVIDE ALL EXCAVATION, SHORING, BACKFILL AND TRENCH RESURFACING PER CITY STANDARD 300. WHERE THE CONNECTION IS TO BE A "HOT TAP," THE CONTRACTOR SHALL PROVIDE AND INSTALL THE TAPPING VALVE AND SLEEVE, AND ANY OTHER HARDWARE REQUIRED AND WILL MAKE THE TAP AT THE DEVELOPER'S EXPENSE. NO HOT TAP SHALL BE MADE WITHIN 4 FEET OF A JOINT (MEASURED FROM JOINT TO CENTERLINE OF INTERSECTING PIPE). THE JOINT SHALL BE REMOVED, AND THE PROPOSED HOT TAP SHALL BE REPLACED WITH A "CUT-IN" TEE. WHEN A "CUT-IN" TEE AND VALVE(S) ASSEMBLY IS REQUIRED ON THE PLANS, THE CONTRACTOR SHALL PROVIDE AND INSTALL THE ENTIRE ASSEMBLY (INCLUDING VALVES), AND ANY OTHER HARDWARE NECESSARY UNDER CITY INSPECTION, AND SHALL PROVIDE ALL OTHER WORK AND MATERIALS NECESSARY TO COMPLETE THE INSTALLATION TO CITY STANDARDS.

14. THE CONTRACTOR SHALL COORDINATE ALL WATER MAIN CONNECTION WORK WITH THE DIRECTOR OF PUBLIC WORKS AT (707) 961-2823 A MINIMUM OF 72 HOURS PRIOR TO COMMENCING WORK IN ACCORDANCE WITH CITY POLICY.

15. WITHIN 48 HOURS OF PAVING, ALL WATER VALVE BOXES WILL BE BROUGHT TO GRADE AND INSPECTED.

16. ALL FIRE HYDRANT FLOW TESTING PERFORMED ON CITY FIRE HYDRANTS SHALL BE PERFORMED BY THE CITY OF FORT BRAGG PUBLIC WORKS DEPARTMENT. THOSE DESIRING FLOW TESTS SHALL NOTIFY THE CITY ENGINEER. PRIOR TO TESTING AND ACCEPTANCE OF HYDRANTS, BURLAP SACKS SHALL BE PLACED OVER HYDRANTS.

CITY OF FORT BRAGG GENERAL NOTES

STD. NO. 100

GENERAL NOTES

3. CONTRACTOR SHALL OBTAIN REQUIRED PERMITS FROM ALL AGENCIES AND PAY ALL FEES PRIOR TO COMMENCEMENT OF ANY WORK.

4. CONTRACTOR SHALL GIVE THE CITY OF FORT BRAGG PUBLIC WORKS DEPARTMENT 48 HOURS NOTICE BEFORE STARTING WORK. CALL (707) 961-2823 OR CONTACT AT 416 N. FRANKLIN STREET, FOR INSPECTION SERVICES.

5. A PRE CONSTRUCTION MEETING IS REQUIRED PRIOR TO BEGINNING OF WORK. CONTACT CITY ENGINEERING TO SCHEDULE MEETING. CALL (707) 961-2823.

6. WORK HOURS ARE LIMITED TO MONDAY THROUGH FRIDAY, 7:00 A.M. TO 6:00 P.M. INSPECTION WILL BE AVAILABLE MONDAY THROUGH FRIDAY FROM 8:00 A.M. TO 4:30 P.M. CONTRACTORS SHALL SCHEDULE INSPECTIONS 48 HOURS IN ADVANCE BY CALLING (707) 961-2823.

7. ANY DISCREPANCY DISCOVERED BY CONTRACTOR IN THESE PLANS OR ANY FIELD CONDITIONS DISCOVERED BY CONTRACTOR THAT MAY DELAY OR OBSTRUCT THE PROPER COMPLETION OF THE WORK PER THESE PLANS SHALL BE BROUGHT TO THE ATTENTION OF THE CITY ENGINEER AND OWNER IMMEDIATELY UPON DISCOVERY. NOTIFICATION SHALL BE IN WRITING.

8. ITEMS SPECIFIED ON THE STANDARD PLANS ARE APPROVED FOR USE BY THE CITY OF FORT BRAGG. ALL SUBSTITUTES OR ALTERATIONS SHALL BE SUBMITTED TO THE CITY OF FORT BRAGG FOR REVIEW AND APPROVAL

12. DURING CONSTRUCTION, THE CONTRACTOR SHALL BE RESPONSIBLE FOR CONTROLLING NOISE, ODORS, DUST AND DEBRIS TO MINIMIZE IMPACTS ON SURROUNDING PROPERTIES AND ROADWAYS. CONTRACTOR SHALL BE RESPONSIBLE TO ASSURE THAT ALL CONSTRUCTION EQUIPMENT IS EQUIPPED WITH MANUFACTURERS APPROVED MUFFLER'S AND BAFFLES. FAILURE TO COMPLY MAY RESULT IN THE ISSUANCE OF A STOP WORK ORDER.

13. IN THE EVENT THAT ARCHEOLOGICAL SITE INDICATORS (CHIPPED CHERT, OBSIDIAN TOOLS, WASTE FLAKES, GRINDING IMPLEMENTS, DARKENED SOIL CONTAINING BONE FRAGMENTS AND SHELLFISH REMAINS, OR CERAMICS, GLASS OR METAL FRAGMENTS) ARE UNCOVERED, THE CITY ENGINEER SHALL BE CONTACTED IMMEDIATELY. ALL GROUND DISTURBING WORK SHALL CEASE IN THE VICINITY OF ANY DISCOVERY UNTIL AN ARCHEOLOGIST COMPLETES AN EVALUATION OF SIGNIFICANCE.

14. IF HAZARDOUS MATERIALS ARE ENCOUNTERED DURING CONSTRUCTION, THE CONTRACTOR SHALL HALT CONSTRUCTION IMMEDIATELY, NOTIFY THE CITY, AND IMPLEMENT REMEDIATION (AS DIRECTED BY THE CITY OR ITS AGENT) IN ACCORDANCE WITH ANY REQUIREMENTS OF THE MENDOCINO COUNTY ENVIRONMENTAL HEALTH DEPARTMENT AND THE NORTH COAST REGIONAL WATER QUALITY CONTROL BOARD.

15. THE CONTRACTOR SHALL BE REQUIRED TO MAINTAIN TRAFFIC FLOW ON AFFECTED ROADWAYS DURING NON-WORKING HOURS, AND TO MINIMIZE TRAFFIC RESTRICTION DURING CONSTRUCTION. NO EXISTING STREET SHALL BE ALLOWED TO BE COMPLETELY CLOSED WITHOUT THE EXPRESSED WRITTEN PERMISSION OF THE DIRECTOR OF PUBLIC WORKS. THE CONTRACTOR SHALL BE REQUIRED TO FOLLOW TRAFFIC SAFETY MEASURES IN ACCORDANCE WITH THE CALTRANS "MANUAL OF TRAFFIC SAFETY CONTROLS FOR CONSTRUCTION AND MAINTENANCE WORK ZONES." THE CITY'S EMERGENCY SERVICE PROVIDERS SHALL BE NOTIFIED OF PROPOSED CONSTRUCTION SCHEDULED BY THE CONTRACTOR(S). THE CONTRACTOR(S) SHALL NOTIFY EMERGENCY SERVICE PROVIDERS IN WRITING AT LEAST 24 HOURS IN ADVANCE OF ITS PROPOSED SCHEDULE OF WORK.

19. CONSTRUCTION TRAFFIC SHALL BE LIMITED TO THE FOLLOWING HAUL ROUTE:
- STATE HIGHWAY 20 TO/FROM PROJECT
- STATE HIGHWAY 20 TO/FROM BENSON LANE, HANSON ROAD, THOMAS LANE
- STATE HIGHWAY 20 TO/FROM SUMMERS LANE, BRUSH CREEK ROAD

NOTIFICATION FOR INSPECTIONS

APPROVAL OF ALL WORK SHALL BE NECESSARY AT THE COMPLETION OF EACH OF THE FOLLOWING STAGES OF WORK AND SUCH APPROVAL MUST BE OBTAINED BEFORE SUBSEQUENT STAGES OF WORK MAY BE COMMENCED. ADDITIONALLY, THE INSPECTOR SHALL BE NOTIFIED AT LEAST 48 HOURS IN ADVANCE OF ANY OF THE FOLLOWING STAGES OF WORK. ANY CONSTRUCTION OR EXCAVATION REQUIRING INSPECTION THAT IS UNDERTAKEN WITHOUT INSPECTION IS SUBJECT TO RECONSTRUCTION AND REEXCAVATION AT THE CONTRACTOR'S EXPENSE. INSPECTION MUST BE SCHEDULED FOR THE FOLLOWING WORK:

1. PRIOR TO COMMENCEMENT OF GRADING ACTIVITIES TO CHECK FOR INSTALLATION OF ADEQUATE TREE PROTECTION FENCING, WHERE APPROPRIATE.

2. COMPACTION AND PREPARATION OF EMBANKMENTS, EXCAVATIONS, AND SUBGRADE.

5. EXCAVATION AND BACK-FILL FOR STRUCTURES AND PIPES AND PUBLIC UTILITIES. WATER AND SEWER FACILITIES MUST BE INSPECTED BY THE COMPANY/AGENCY WITH JURISDICTION, INCLUDING PRIVATE FACILITIES.

6. CONSTRUCTION OF ROADSIDE DITCHES AND OTHER DRAINAGE WAYS.

7. PLACING AND COMPACTING OF BASE MATERIAL. IF MORE THAN ONE COURSE OR TYPE OF BASE OR SUBBASE IS TO BE USED, APPROVAL SHALL BE NECESSARY FOR EACH COURSE AND/OR TYPE.

8. PLACING OF PAVEMENT OR SURFACING. WITHIN 48 HOURS OF PAVING, ALL WATER VALVE BOXES, CLEANOUTS AND MANHOLE FRAMES AND COVERS SHALL BE BROUGHT TO GRADE AND INSPECTED.

10. FINAL CLEAN UP.

GRADING NOTES

3. STREET SUB GRADE SHALL BE COMPACTED TO 95% RELATIVE COMPACTION TO A DEPTH OF NO LESS THAN 6" IN THE ROADWAY SECTION. ASPHALT CONCRETE AND CLASS 2 AGGREGATE BASE SHALL BE COMPACTED TO 95% RELATIVE COMPACTION.

4. THE USE OF THE SAND CONE METHODS (SUCH AS ASTM 1557 OR CAL 216) FOR DETERMINING FIELD DENSITIES WILL NOT BE ALLOWED AS A SUBSTITUTE FOR NUCLEAR GAUGE TESTING.

6. ANY EXCESS MATERIALS SHALL BE CONSIDERED THE PROPERTY OF THE CONTRACTOR AND SHALL BE DISPOSED OF AWAY FROM THE JOB SIDE IN ACCORDANCE WITH APPLICABLE LOCAL, STATE AND FEDERAL REGULATIONS.

7. ALL TREE PROTECTION FENCING MUST BE INSTALLED AND INSPECTED PRIOR TO COMMENCEMENT OF GRADING OPERATIONS. FENCING SHALL BE MAINTAINED THROUGHOUT

DUST CONTROL NOTES

1. THE CONTRACTOR SHALL BE RESPONSIBLE TO PROVIDE DUST CONTROL MEASURES FOR THE ENTIRE CONSTRUCTION PERIOD OF THIS PROJECT TO THE SATISFACTION OF THE CITY ENGINEER.

2. CONSTRUCTION EQUIPMENT SHALL BE MAINTAINED IN PROPER WORKING ORDER AND SHALL NOT BE ALLOWED TO IDLE FOR A PERIOD OF LONGER THAN 30 MINUTES.

3. TO MINIMIZE FUGITIVE DUST AND THE RELEASE OF PM10, THE CONTRACTOR SHALL IMPLEMENT A DUST CONTROL PROGRAM. DUST CONTROL MEASURES SHALL INCLUDE, BUT ARE NOT LIMITED TO, THE FOLLOWING:

A. ACTIVE CONSTRUCTION SITE SHALL BE WATERED AS NEEDED, PREFERABLE IN THE LATE MORNING AND WHEN WORK HAS CEASED FOR THE DAY.
B. STOCKPILES OF LOOSE MATERIAL SHALL BE COVERED AT ALL TIMES, EXCEPT WHEN THIS WOULD INTERFERE WITH IMMEDIATE CONSTRUCTION ACTIVITIES.
C. ALL CLEARING, GRADING, EARTH MOVING OR EXCAVATION ACTIVITIES SHALL CEASE WHEN THE AVERAGE WIND SPEED FOR ONE HOUR EXCEEDS 20 MILES PER HOUR (MPH).
D. THE AREA DISTURBED BY EXCAVATION OR GRADING SHALL BE KEPT TO THE MINIMUM REQUIRED TO IMPLEMENT THE PROJECT.
E. WHEN TRAVELING ON EXPOSED SOILS, CONSTRUCTION SITE VEHICLE SPEED SHALL BE LIMITED TO 15 MPH.
F. HAUL VEHICLES SHALL BE COVERED WHEN NOT ACTIVELY ENGAGED IN SITE CONSTRUCTION ACTIVITY.
G. STREETS SHALL BE SWEPT REGULARLY AND KEPT FREE OF DIRT AND DEBRIS.

4. ANY PROJECT RELATED DEBRIS, DEBRIS AND WASTE SHALL BE DISPOSED OF IN ACCORDANCE WITH APPLICABLE FEDERAL, STATE AND LOCAL STATUES AND REGULATIONS.

CITY OF FORT BRAGG GENERAL NOTES (CONTINUED)

STD. NO. 100

EROSION CONTROL NOTES

1. A NOTICE OF INTENT (NOI) SHALL BE FILED BY THE CITY FOR THIS PROJECT. THE CONTRACTOR SHALL COMPLY WITH ALL REQUIREMENTS OF THE SWPPP PERMIT.

2. EROSION CONTROL MEASURES SHALL BE INSTALLED AND IN PLACE BETWEEN OCTOBER 1 AND MAY 1. INSTALLATION SHALL BE IN ACCORDANCE WITH THE APPROVED EROSION CONTROL PLAN.

3. THE CONTRACTOR SHALL BE RESPONSIBLE FOR CONSTANT MAINTENANCE OF EROSION CONTROL MEASURES. SITE EROSION CONTROL SHALL BE INSPECTED BY THE CONTRACTOR AND CLEANED IF NECESSARY AFTER EVERY MAJOR STORM.

4. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE CLEANUP OF MUD AND DEBRIS CARRIED ONTO SURROUNDING STREETS TO THE SATISFACTION OF THE CITY ENGINEER.

5. ALL GRADED AREAS AND EXPOSED SOIL WITHIN THIS PROJECT SHALL BE SEEDED FOR EROSION CONTROL BY THE CONTRACTOR. SEED AND MULCH WILL BE APPLIED BY OCTOBER 1ST TO ALL CUT AND FILL SLOPES WITHIN OR ADJACENT TO PROJECT ROADS. SEED AND FERTILIZER WILL BE APPLIED HYDRAULICALLY OR BY HAND AT THE RATES SPECIFIED BELOW. ON SLOPES, STRAW WILL BE APPLIED BY BLOWER OR BY HAND AND ANCHORED IN PLACE BY PUNCHING.

6. HYDROSEEDING MIX SHALL CONFORM TO THE FOLLOWING:

ITEM	POUNDS PER ACRE
"BLANDO BROME"	30
ANNUAL RYE GRASS	20
FERTILIZER (16-20-0 & 15% SULFUR)	500
STRAW MULCH	4000 OR 3500 LB. OF WOOD CELLULOSE

7. ALL CRITICAL EARTHWORK OPERATIONS SHALL BE PERFORMED DURING THE DRY WEATHER SEASON, FROM MAY 1ST TO OCTOBER 1ST OR AS OTHERWISE APPROVED BY THE CITY ENGINEER. THE CLEARING OF EXISTING VEGETATION SHALL BE CONFINED TO WITHIN THE LIMITS OF ACTUAL EARTHWORK. INCREMENTAL DEVELOPMENT SHALL BE REQUIRED TO ENSURE THAT THE AMOUNT OF LAND CLEARED AT ANY TIME IS LIMITED TO THE AREA THAT CAN BE DEVELOPED DURING THE CONSTRUCTION PERIOD. STORM WATER SHALL NOT BE ALLOWED TO FLOW DIRECTLY DOWN UNPROTECTED SLOPES. ENERGY DISSIPATING STRUCTURES AND EROSION CONTROL DEVICES SHALL BE PLACED AT ALL DRAINAGE OUTLETS WHICH DISCHARGE TO NATURAL CHANNELS AS SHOWN ON THESE PLANS. ALL SEDIMENT TRAPS SHALL BE MAINTAINED BY THE OWNER UNTIL SUCH TIME AS THE CITY ACCEPTS MAINTENANCE RESPONSIBILITY.

GENERAL UNDERGROUND NOTES

1. NO GUARANTEE IS INTENDED THAT UNDERGROUND OBSTRUCTIONS, NOT SHOWN ON THESE PLANS, WILL NOT BE ENCOUNTERED. THOSE SHOWN ARE BASED ON THE BEST INFORMATION AVAILABLE AND THE CONTRACTOR IS CAUTIONED THAT KASL CONSULTING ENGINEERS AND THE CITY OF FORT BRAGG ASSUME NO RESPONSIBILITY FOR ANY OBSTRUCTIONS EITHER SHOWN OR NOT SHOWN ON THESE PLANS. THE CONTRACTOR SHALL COOPERATE WITH ALL UTILITY COMPANIES WORKING WITHIN THE LIMITS OF THIS PROJECT.

2. CONTRACTOR SHALL NOT BEGIN EXCAVATION UNTIL ALL EXISTING UTILITIES HAVE BEEN MARKED IN THE FIELD BY THE APPLICABLE ENTITY RESPONSIBLE FOR THAT PARTICULAR UTILITY. THE CONTRACTOR SHALL NOTIFY EACH APPLICABLE ENTITY AT LEAST 24 HOURS BEFORE STARTING WORK. HAND DIGGING IS REQUIRED IF TRENCH IS WITHIN 12" OF ANY EXISTING UTILITY.

3. UNDERGROUND SERVICE ALERT: CALL TOLL FREE (800) 642-2444 AT LEAST 48 HOURS PRIOR TO EXCAVATION.

4. THE CONTRACTOR SHALL OBTAIN A TRENCH PERMIT FROM THE CALIFORNIA DIVISION OF INDUSTRIAL SAFETY BEFORE EXCAVATION OF TRENCHES IN EXCESS OF 5 FEET IN DEPTH. A COPY OF THE PERMIT MUST BE ON FILE WITH THE CITY BEFORE TRENCH EXCAVATION MAY BEGIN.

5. CONTRACTOR SHALL UNCOVER EXISTING BURIED UTILITIES WITH UTILITY OR PROPERTY OWNER TO VERIFY LOCATIONS AND ELEVATIONS OF UTILITIES. BURIED UTILITIES MAY INCLUDE BUT ARE NOT LIMITED TO WATER MAINS AND LATERALS, SEPTIC TANKS AND LEACH FIELDS, STORM DRAINS, GAS MAINS AND LATERALS, ELECTRICAL DISTRIBUTION LINES, CABLE TELEVISION LINES, AND TELEPHONE LINES. ALL UTILITIES CONFLICTING WITH THE PROPOSED CONSTRUCTION SHALL BE RELOCATED TO THE SATISFACTION OF THE OWNER BEFORE THE START OF CONSTRUCTION.

6. THE CONTRACTOR SHALL VERIFY EXISTING INVERTS PRIOR TO THE COMMENCEMENT OF ANY CONSTRUCTION. THE PROJECT AND/OR DESIGN ENGINEER MAY ADJUST THE GRADE OF NEW SEWER AND STORM DRAIN CONSTRUCTION ACCORDINGLY WITH CONCURRENCE FROM THE CITY ENGINEER.

7. DISTANCES AND INVERTS ARE TO AND AT THE CENTER OF THE MANHOLES, CLEANOUTS, DROP INLETS, CATCH BASINS, AND YARD DRAINS OR AS MARKED ON THE DRAWINGS.

8. ALL UNDERGROUND IMPROVEMENTS SHALL BE INSTALLED AND APPROVED PRIOR TO PAVING.

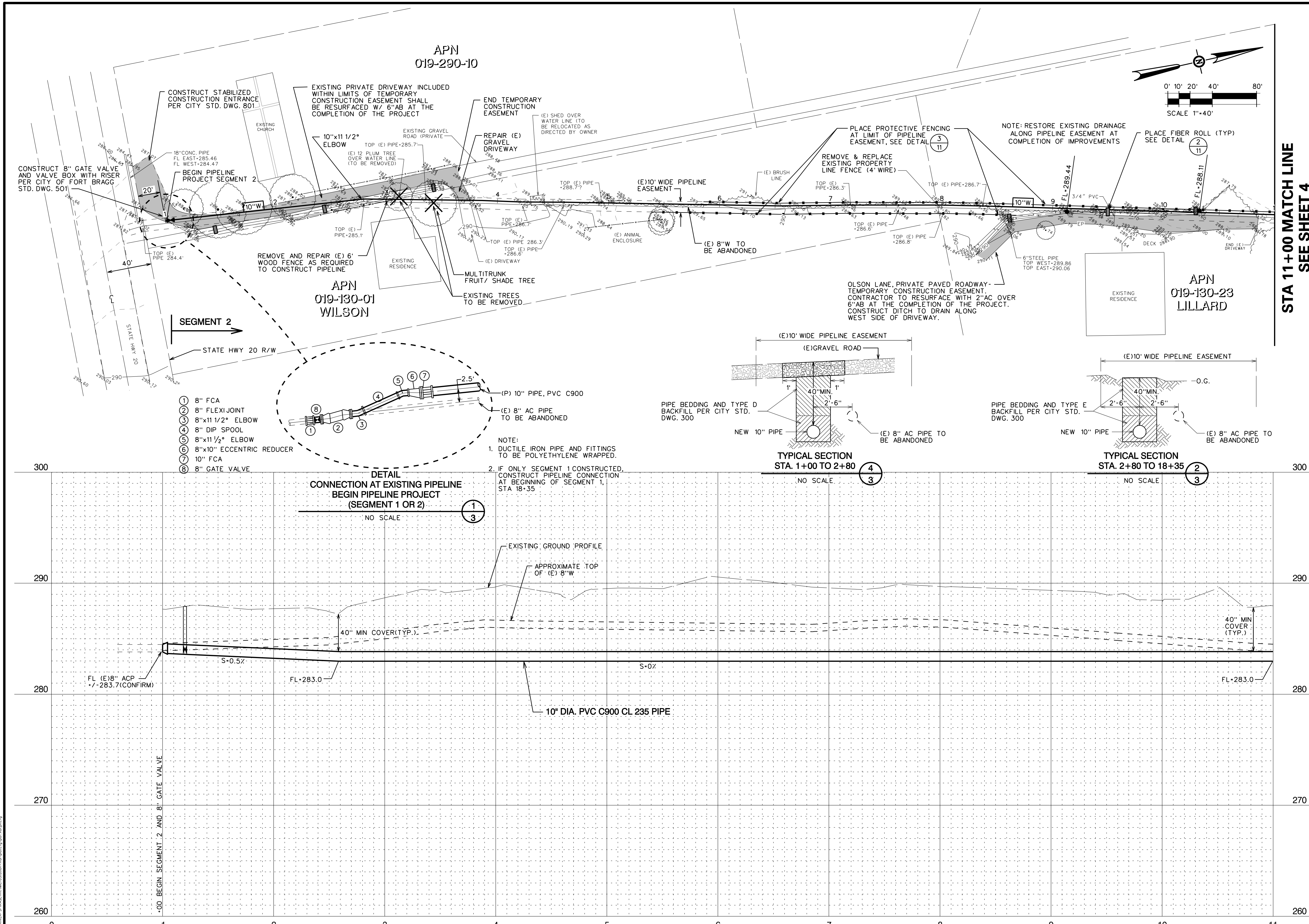
REVISIONS			
NO.	DESCRIPTION	DATE	BY

BENCHMARK FORT BRAGG DATUM
ELEV. ____ DATUM: NAVD 88
SCALE: N/A N/A
JOB NO. 2719-02
RELEASE 4 OCT. 2010

IMPROVEMENT PLANS FOR CONSTRUCTION OF
WATERFALL GULCH TRANSMISSION MAIN
STATE HIGHWAY 20 TO BRUSH CREEK ROAD
FORT BRAGG, CALIFORNIA

GENERAL NOTES

CONSULTING KASL ENGINEERS
7777 Greenback Lane
Suite 104
Citrus Heights, CA 95610
Tel. (916) 722-1800
Fax (916) 722-4595
CIVIL - WATER RESOURCES - SURVEYING



REVISIONS

NO.	DESCRIPTION	DATE	BY

BENCHMARK FORT BRAGG DATUM

ELEV. DATUM: NAVD 88

RELEASE 4 OCT. 2010

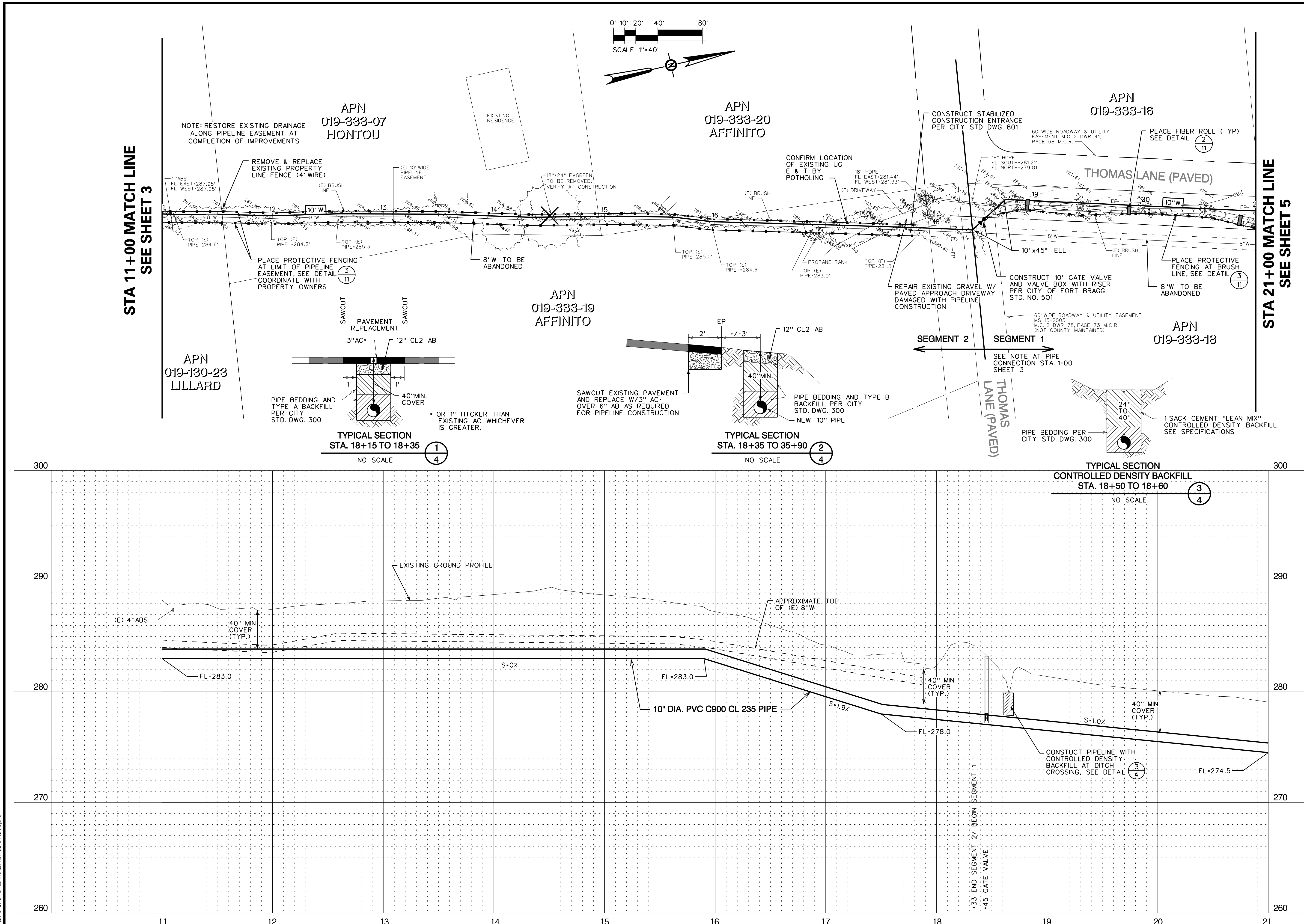
SCALE: HORIZ. 1"=40' VERT. 1"=4'

JOB NO. 2719-02

IMPROVEMENT PLANS FOR CONSTRUCTION OF
WATERFALL GULCH TRANSMISSION MAIN
STATE HIGHWAY 20 TO BRUSH CREEK ROAD
FORT BRAGG, CALIFORNIA

PLAN AND PROFILE SHEET 1
STA. 1+00 TO 11+00

KASL CONSULTING ENGINEERS
7777 Greenback Lane Suite 104 Citrus Heights, CA 95610 Tel. (916) 722-1800 Fax (916) 722-4595
CIVIL - WATER RESOURCES - SURVEYING



REVISIONS

NO.	DESCRIPTION	DATE	BY

BENCHMARK
FORT BRAGG DATUM

ELEV. ___
DATUM: NAVD 88

SCALE: HORIZ. 1"=40'
VERT. 1"=4'

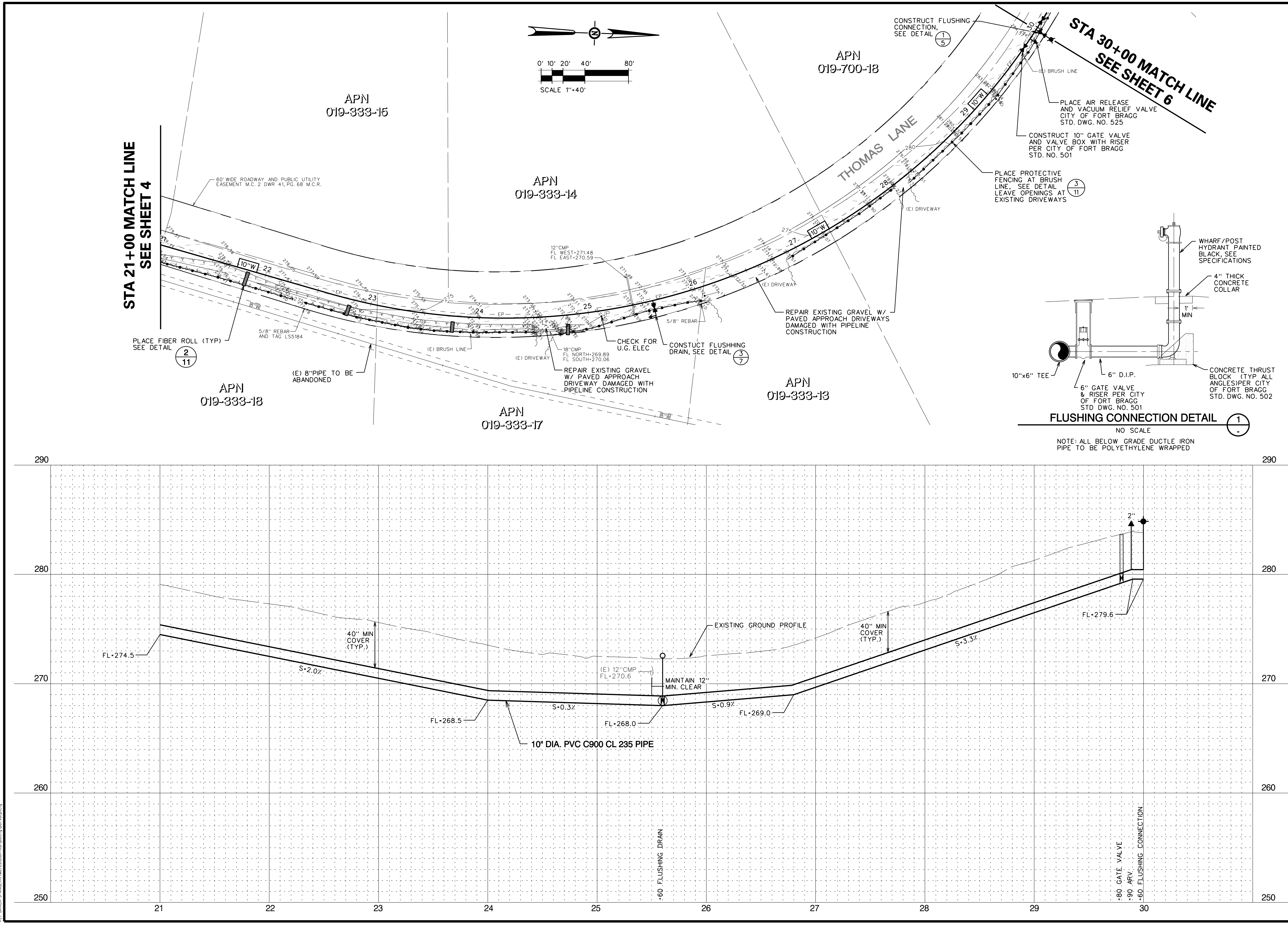
RELEASE 4
OCT. 2010

JOB NO. 2719-02

IMPROVEMENT PLANS FOR CONSTRUCTION OF
WATERFALL GULCH TRANSMISSION MAIN
STATE HIGHWAY 20 TO BRUSH CREEK ROAD
FORT BRAGG, CALIFORNIA

PLAN AND PROFILE SHEET 2
STA. 11+00 TO 21+00

KASL CONSULTING ENGINEERS
7777 Greenback Lane
Suite 104
Citrus Heights, CA 95610
Tel. (916) 722-1800
Fax (916) 722-4595
CIVIL - WATER RESOURCES - SURVEYING



NO.	DESCRIPTION	DATE	BY

REVISIONS

BENCHMARK
FORT BRAGG DATUM
ELEV. ___
DATUM: NAVD 88

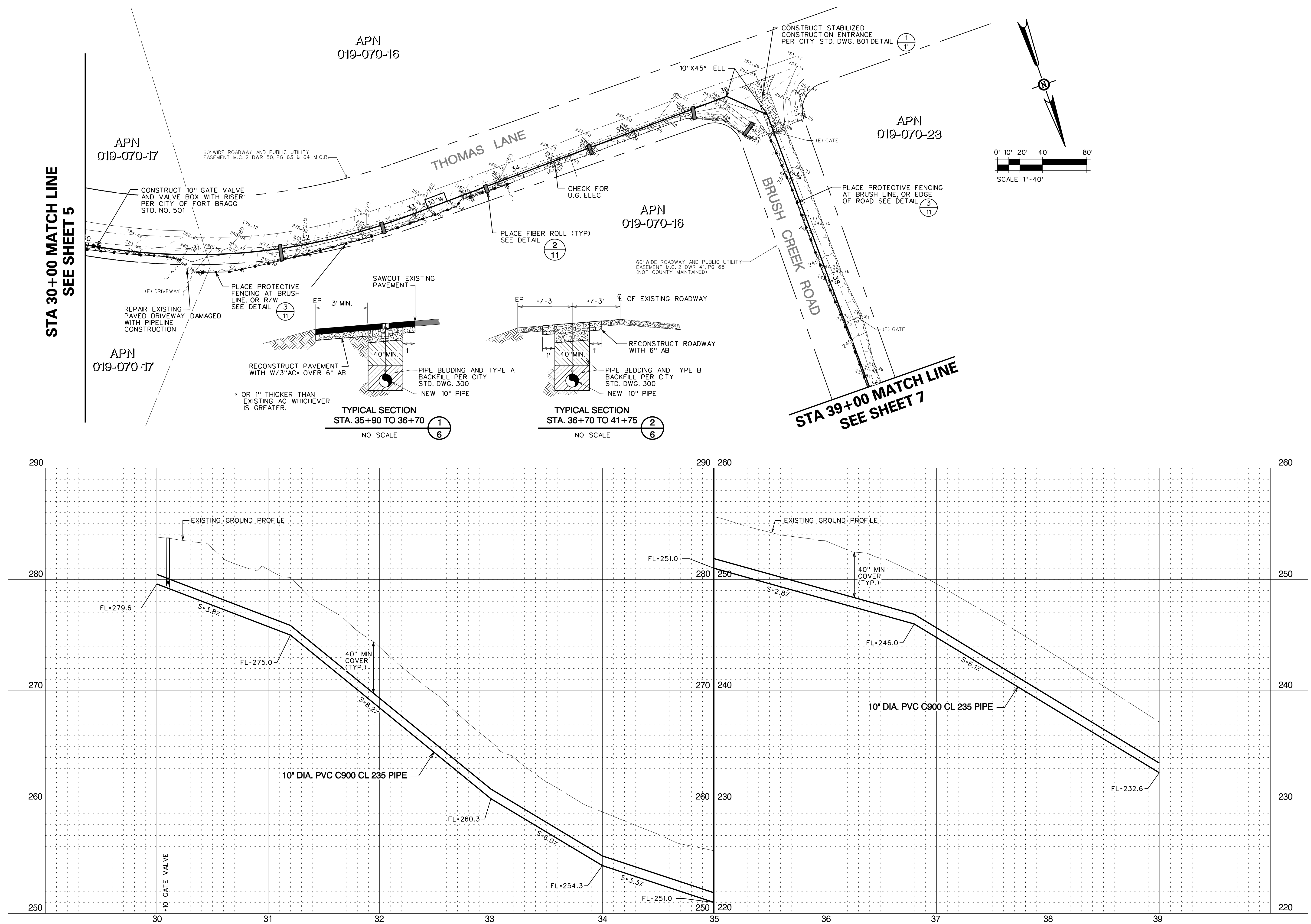
RELEASE 4
OCT. 2010

SCALE: HORIZ. 1"=40' VERT. 1"=4'
JOB NO. 2719-02

IMPROVEMENT PLANS FOR CONSTRUCTION OF
WATERFALL GULCH TRANSMISSION MAIN
STATE HIGHWAY 20 TO BRUSH CREEK ROAD
FORT BRAGG, CALIFORNIA

PLAN AND PROFILE SHEET 3
STA 21+00 TO 30+00

CONSULTING KASL ENGINEERS
7777 Greenback Lane
Suite 104
Citrus Heights, CA 95610
Tel. (916) 722-1800
Fax (916) 722-4595
CIVIL - WATER RESOURCES - SURVEYING



NO.	DESCRIPTION	DATE	BY
	REVISIONS		

BENCHMARK
FORT BRAGG DATUM
ELEV.
DATUM: NAVD 88

SCALE: HORIZ. 1"=40' VERT. 1"=4'
JOB NO. 2719-02

RELEASE 4
OCT. 2010

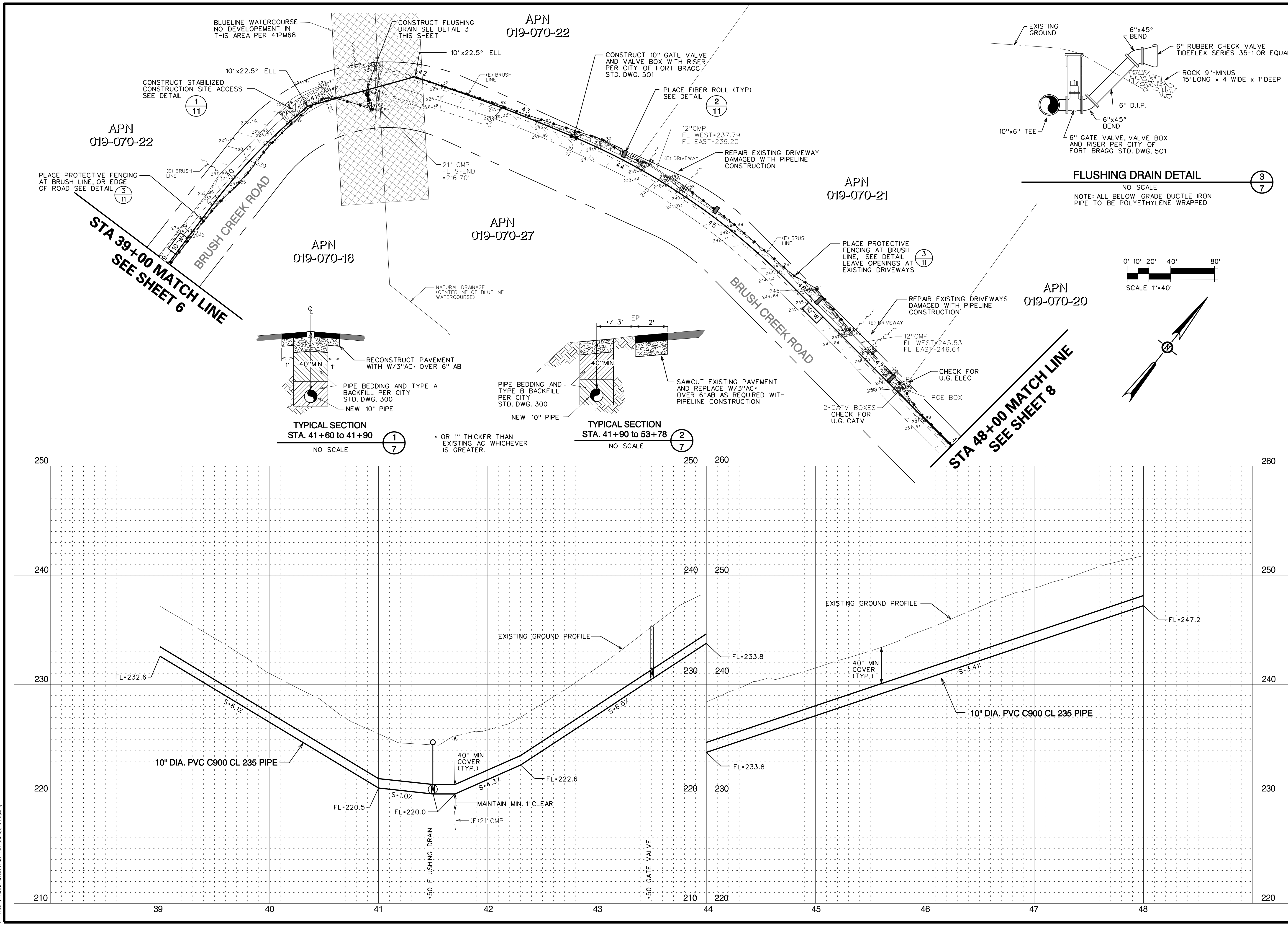
REGISTERED PROFESSIONAL ENGINEER
STATE OF CALIFORNIA

IMPROVEMENT PLANS FOR CONSTRUCTION OF
WATERFALL GULCH TRANSMISSION MAIN
STATE HIGHWAY 20 TO BRUSH CREEK ROAD
FORT BRAGG, CALIFORNIA

PLAN AND PROFILE SHEET 4

KASL CONSULTING ENGINEERS
7777 Greenback Lane
Suite 104
Citrus Heights, CA 95610
Tel. (916) 722-1800
Fax (916) 722-4595
CIVIL - WATER RESOURCES - SURVEYING

SHEET 6 OF 11



REVISIONS			
NO.	DESCRIPTION	DATE	BY

BENCHMARK
FORT BRAGG DATUM

ELEV. DATUM: NAVD 88

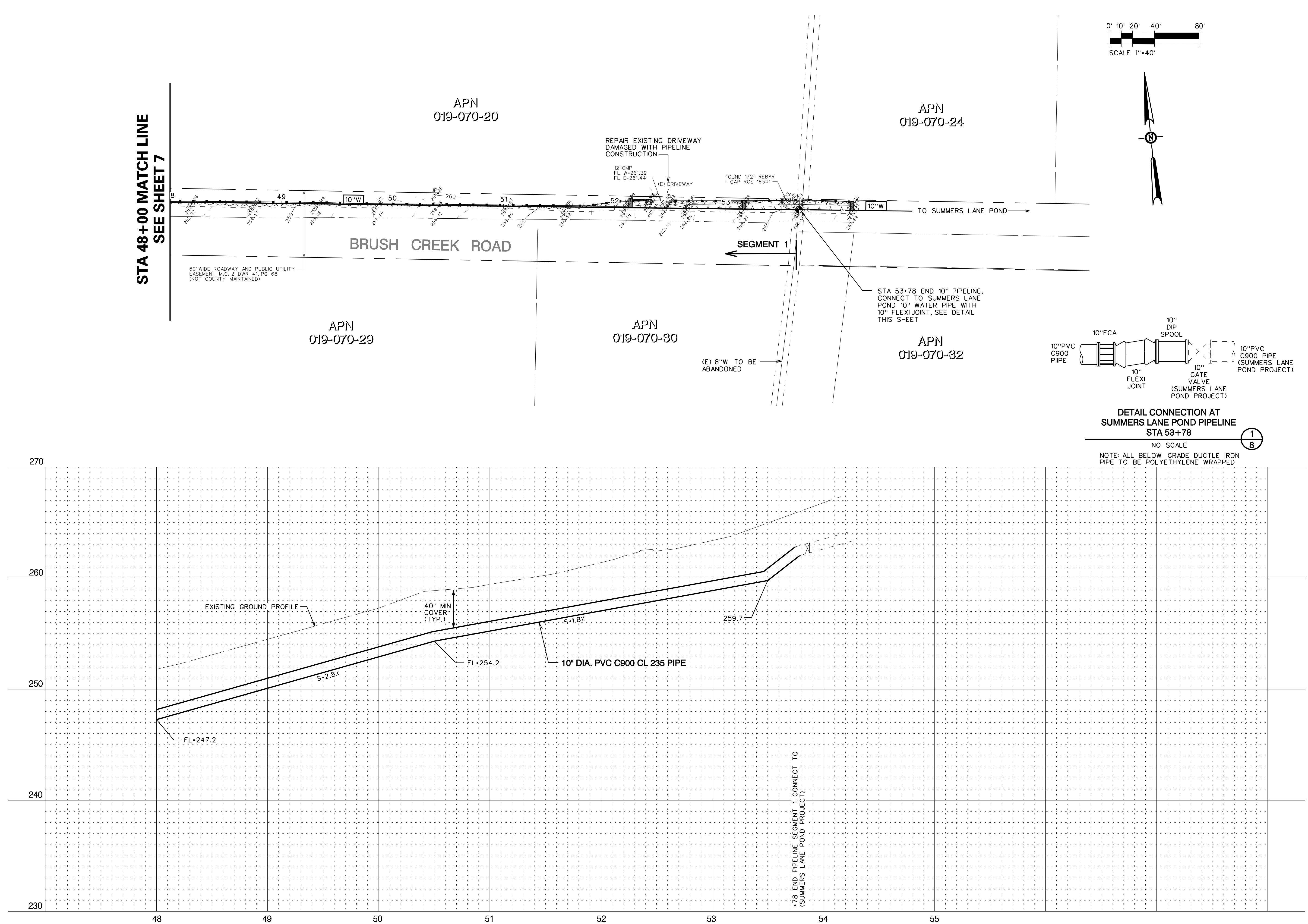
RELEASE 4
OCT. 2010

SCALE: HORIZ. 1"=40' VERT. 1"=4'
JOB NO. 2719-02

IMPROVEMENT PLANS FOR CONSTRUCTION OF
WATERFALL GULCH TRANSMISSION MAIN
STATE HIGHWAY 20 TO BRUSH CREEK ROAD
FORT BRAGG, CALIFORNIA

PLAN AND PROFILE SHEET 5
STA. 39+00 TO 48+00

CONSULTING KASL ENGINEERS
7777 Greenback Lane
Suite 104
Citrus Heights, CA 95610
Tel. (916) 722-1800
Fax (916) 722-4595
CIVIL - WATER RESOURCES - SURVEYING



REVISIONS

NO.	DESCRIPTION	DATE	BY

BENCHMARK
FORT BRAGG DATUM

ELEV.
DATUM: NAVD 88

SCALE: HORIZ. 1"=40'
VERT. 1"=4'

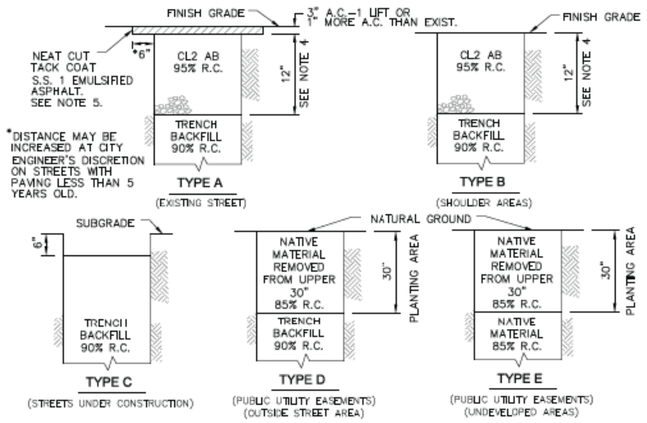
RELEASE 4
OCT. 2010

JOB NO. 2719-02

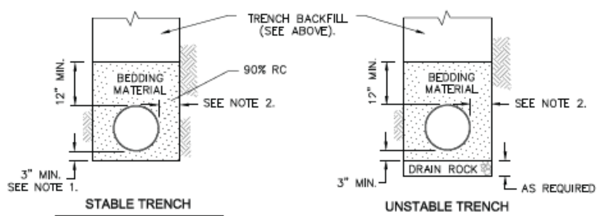
IMPROVEMENT PLANS FOR CONSTRUCTION OF
WATERFALL GULCH TRANSMISSION MAIN
STATE HIGHWAY 20 TO BRUSH CREEK ROAD
FORT BRAGG, CALIFORNIA

PLAN AND PROFILE SHEET 6
STA 48+00 TO END

CONSULTING
KASL
ENGINEERS
7777 Greenback Lane
Suite 104
Citrus Heights, CA 95610
Tel. (916) 722-1800
Fax (916) 722-4595
CIVIL - WATER RESOURCES - SURVEYING



TRENCH BACKFILL AND SURFACING



PIPE BEDDING

NOTES:

1. 1/4 PIPE O.D. OR 4" MIN. WHEN EXCAVATION IS IN ROCKY GROUND.
2. PIPE DIAMETER 18" OR LESS: 6" MIN., 9" MAX. PIPE DIAMETER GREATER THAN 18": 9" MIN., 12" MAX.
3. RELATIVE COMPACTION DESIGNATED R.C.
4. THE STREET STRUCTURAL SECTION SHALL BE A MIN. OF 3" A.C. ON 12" A.B. OR MATCH EXISTING PAVEMENT THICKNESS PLUS 1" A.C., WHICHEVER IS THICKER OR AS SPECIFIED ON PLANS.
5. NEATLY CUT PAVEMENT SIX INCHES FROM EDGE OF TRENCH AFTER TRENCH IS BACKFILLED.

SHEET 1 OF 2

CITY OF FORT BRAGG CALIFORNIA

STANDARD TRENCH DETAIL — STD. NO. 300

SCALE: NONE	DRAWN: LMM	CHK: OAB	APPVD:	DATE: APR 2008

MATERIAL SPECIFICATIONS:

DRAIN ROCK SHALL BE EITHER OF THE NOMINAL SIZES DESIGNATED AS 1-1/2" BY 3/4" OR 2-1/2" BY 1-1/2".

PIPE BEDDING AND TRENCH BACKFILL MATERIAL SHALL BE A WELL GRADED AGGREGATE (PEA GRAVEL WILL NOT BE ACCEPTED) MATERIAL AND SHALL HAVE A MINIMUM SAND EQUIVALENT VALUE OF 30 AND SHALL CONFORM TO THE FOLLOWING GRADINGS:

	PERCENT PASSING			
	3"	1"	3/4"	NO. 4
PIPE BEDDING		100	95-100	55-100
TRENCH BACKFILL	100			40-100

AGGREGATE BASE SHALL BE CLASS 2, 1-1/2" MAX. OR 3/4" MAX CONFORMING TO THE PROVISIONS OF SECTION 26 OF THE STATE STANDARD SPECIFICATIONS.

NATIVE MATERIAL SHALL NOT CONTAIN ROCKS LARGER THAN 3".

COMPACTION REQUIREMENTS: (AS SHOWN ON SHEET 1 AND IN THE FOLLOWING MODIFICATIONS).

DRAIN ROCK SHALL BE CONSOLIDATED WITH A SURFACE VIBRATOR.

PIPE BEDDING MATERIAL USED TO GRADE THE TRENCH SHALL BE CONSOLIDATED WITH A SURFACE VIBRATOR WHEN IT IS PLACED OVER DRAIN ROCK OR WHEN DEPTH IS GREATER THAN 12".

PIPE BEDDING MATERIAL SHALL EITHER BE HAND TAMPED UNDER AND AT THE SIDES OF THE PIPE IN LIFTS NOT GREATER THAN 6" OR SHAPED AND COMPACTED PRIOR TO PIPE INSTALLATION.

GENERAL: THE COMPACTION REQUIREMENTS SHALL BE ACHIEVED UTILIZING METHODS AND EQUIPMENT APPROVED BY THE CITY. ANY METHOD OF COMPACTION WHICH FAILS TO UNIFORMLY ACHIEVE THE REQUIRED LEVELS OF COMPACTION THROUGHOUT THE LENGTH AND DEPTH OF TRENCHES SHALL BE DISCONTINUED. COMPACTION METHODS AND EQUIPMENT SHALL BE SUCH AS NOT TO DAMAGE THE INSTALLED PIPE, EXCEED ITS LOADING CAPACITY, OR DISTURB ITS ALIGNMENT. FLOODING, PONDING, OR THE USE OF DROP HAMMER TYPE COMPACTION EQUIPMENT WILL NOT BE ALLOWED.

MECHANICAL COMPACTION: TRENCH BACKFILL SHALL BE PLACED IN UNIFORM, HORIZONTAL LAYERS NOT EXCEEDING EIGHT (8) INCHES IN THICKNESS BEFORE COMPACTION. EACH LAYER SHALL BE COMPACTED, USING MECHANICAL MEANS, TO THE SPECIFIED DENSITY SHOWN ON THE PLANS.

THE CONTRACTOR MAY, AT HIS SOLE OPTION AND AT HIS SOLE EXPENSE, CONSTRUCT A TEST TRENCH SECTION WHICH DEMONSTRATES METHODS, EQUIPMENT, OR MATERIALS WHICH WILL RELIABLY ACHIEVE THE REQUIRED COMPACTION IN LIFTS GREATER THAN 8 INCHES. AT ITS SOLE DISCRETION, THE CITY MAY INCREASE THE MAXIMUM ALLOWABLE LIFT THICKNESS PERMITTED BASED UPON THE RESULTS DEMONSTRATED BY THE TEST TRENCH SECTION. SHOULD SUBSEQUENT TESTING DEMONSTRATE THAT THE REQUIRED COMPACTION IS NOT BEING RELIABLY ACHIEVED, THE CITY MAY, AT ITS SOLE DISCRETION, REDUCE THE MAXIMUM LIFT THICKNESS TO ITS ORIGINAL VALUE OF 8 INCHES.

JETTING: JETTING IS NOT ALLOWED.

SHEET 2 OF 2

CITY OF FORT BRAGG CALIFORNIA

STANDARD TRENCH DETAIL — STD. NO. 300

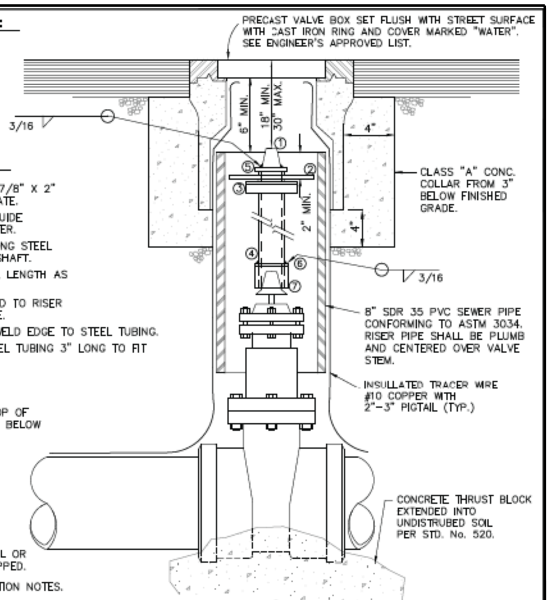
SCALE: NONE	DRAWN: LMM	CHK: OAB	APPVD:	DATE: APR 2008

STEM EXTENSION FABRICATION NOTES:

1. ALL WELDS TO RISER SHAFT SHALL BE FILLET WELD ALL AROUND.
2. ALL STEEL REQUIRED FOR RISER FABRICATION SHALL BE STRUCTURAL STEEL PER ASTM A36.

VALVE STEM EXTENSION PARTS LIST:

1. VALVE OPERATING NUT OR 1 7/8" X 1 7/8" X 2" HIGH, SOLID STEEL WELDED TO TOP PLATE.
2. 3/16" THK. X 7" DIA. FREE SPINNING GUIDE PLATE WITH 3 5/8" DIA. HOLE IN CENTER.
3. TWO 3/16" X 1 1/2" X 1 1/2" X 5" LONG STEEL ANGLE WELD TO TWO SIDES OF RISER SHAFT.
4. 2 1/2" X 3/16" SQUARE STEEL TUBING, LENGTH AS REQUIRED. EDGE WELD TO TOP PLATE.
5. 3" X 3" X 1/4" STEEL TOP PLATE. WELD TO RISER SHAFT AFTER GUIDE PLATE IS IN PLACE.
6. 2" X 2" X 1/4" STEEL BASE PLATE. WELD EDGE TO STEEL TUBING.
7. 2" X 2" X 3/16" SQ. STRUCTURAL STEEL TUBING 3" LONG TO FIT OPERATING NUT.



NOTES:

1. IF VALVE IS INSTALLED SO THAT THE TOP OF THE OPERATING NUT IS LESS THAN 30" BELOW FINISHED GRADE, THE VALVE STEM RISER IS NOT REQUIRED.
2. VALVES 2" THROUGH 16" SHALL BE RESILIENT WEDGE GATE VALVES AND VALVES 18" AND LARGER SHALL BE BUTTERFLY VALVES (SEE STD 522) UNLESS OTHERWISE APPROVED BY THE CITY.
3. ALL EXTERNAL BOLTS AND NUTS ON VALVES SHALL BE 304 STAINLESS STEEL OR VALVE ASSEMBLY SHALL BE POLY WRAPPED.
4. SEE STD. 500 FOR GENERAL CONSTRUCTION NOTES.
5. NOTE ON DRAWING: "VALVE EXTENSIONS MUST BE INSTALLED PRIOR TO FINAL INSPECTION".
6. GATE VALVE ILLUSTRATED. SIMILAR INSTALLATION REQUIRED FOR BALL VALVES & BUTTERFLY VALVES.

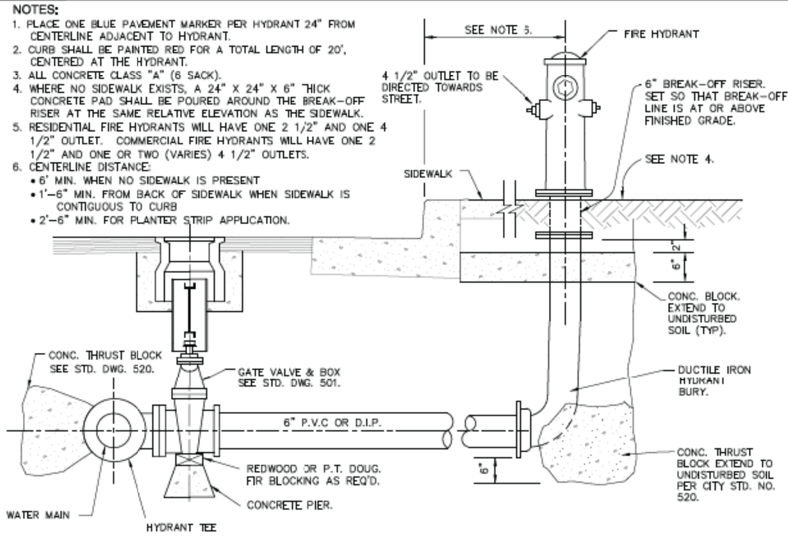
CITY OF FORT BRAGG CALIFORNIA

GATE VALVE AND VALVE BOX WITH RISER — STD. NO. 501

SCALE: NONE	DRAWN: LMM	CHK: OAB	APPVD:	DATE: APR 2008

NOTES:

1. PLACE ONE BLUE PAVEMENT MARKER PER HYDRANT 24" FROM CENTERLINE ADJACENT TO HYDRANT.
2. CURB SHALL BE PAINTED RED FOR A TOTAL LENGTH OF 20', CENTERED AT THE HYDRANT.
3. ALL CONCRETE CLASS "A" (6 SACK).
4. WHERE NO SIDEWALK EXISTS, A 24" X 24" X 6" THICK CONCRETE PAD SHALL BE POURED AROUND THE BREAK-OFF RISER AT THE SAME RELATIVE ELEVATION AS THE SIDEWALK.
5. RESIDENTIAL FIRE HYDRANTS WILL HAVE ONE 2 1/2" AND ONE 4 1/2" OUTLET. COMMERCIAL FIRE HYDRANTS WILL HAVE ONE 2 1/2" AND ONE OR TWO (VARIES) 4 1/2" OUTLETS.
6. CENTERLINE DISTANCE:
   - 6' MIN. WHEN NO SIDEWALK IS PRESENT
   - 1'-6" MIN. FROM BACK OF SIDEWALK WHEN SIDEWALK IS CONTIGUOUS TO CURB
   - 2'-6" MIN. FOR PLANTER STRIP APPLICATION.



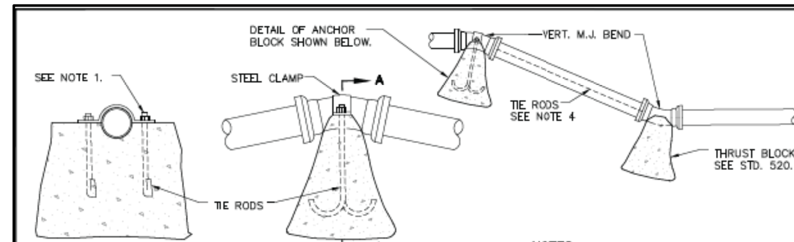
NOTES (CONTINUED):

7. VERIFY FIRE PROTECTION REQUIREMENTS WITH THE FORT BRAGG FIRE PROTECTION DISTRICT.
8. INSTALL HYDRANTS WITH MINIMUM 3' CLEARANCE FROM OBSTRUCTIONS AND 10' CLEAR OF DRIVEWAYS EXCEPT AS OTHERWISE REQUIRED OR APPROVED.
9. SEE ENGINEER'S APPROVED LIST FOR HYDRANT MODELS.
10. ALL HYDRANTS SHALL BE PAINTED "SAFETY YELLOW".

CITY OF FORT BRAGG CALIFORNIA

FIRE HYDRANT INSTALLATION — STD. NO. 502

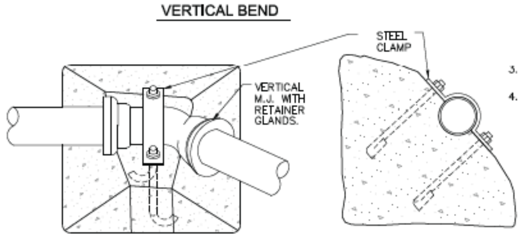
SCALE: NONE	DRAWN: CLG	CHK: HEU	APPVD:	DATE: JAN 2009



SECTION "A-A"

ELEVATION

TYPICAL CONCRETE ANCHOR BLOCK FOR VERTICAL BEND



TYPICAL CONCRETE ANCHOR BLOCK FOR COMBINATION HORIZONTAL-VERTICAL BEND

NOTES:

1. ALL EXPOSED THREADS SHALL BE PAINTED WITH BITUMASTIC OR APPROVED EQUAL, AFTER NUTS ARE TIGHTENED.
2. CONCRETE ANCHOR BLOCKS SHALL BE INSTALLED BY THE CONTRACTOR TO WITHSTAND A THRUST PRODUCED BY THE TEST PRESSURE PLUS 50 P.S.I. MINIMUM DIMENSIONS FOR TIE RODS AND CLAMPS ARE LISTED IN THE TABLE BELOW.
3. USE MECHANICAL JOINT RETAINER GLANDS AT ALL FITTINGS.
4. FOR PVC PIPE, TIE RODS (THREADED FULL LENGTH) BETWEEN FITTINGS (MIN. 2 REQD.) MAY BE USED IN LIEU OF RETAINING GLANDS.

PIPE SIZE	TIE RODS	STEEL CLAMPS
6"	5/8"	3" X 1/4"
8"	3/4"	3-1/4" X 1/4"
12"	1-1/4"	4" X 1/2"

CITY OF FORT BRAGG CALIFORNIA

CONCRETE ANCHOR BLOCKS FOR VERTICAL BENDS — STD. NO. 519

SCALE: NONE	DRAWN: LMM	CHK: OAB	APPVD:	DATE: APR 2008

REVISIONS			
NO.	DESCRIPTION	DATE	BY

BENCHMARK
FORT BRAGG DATUM
ELEV. ____
DATUM: NAVD 88

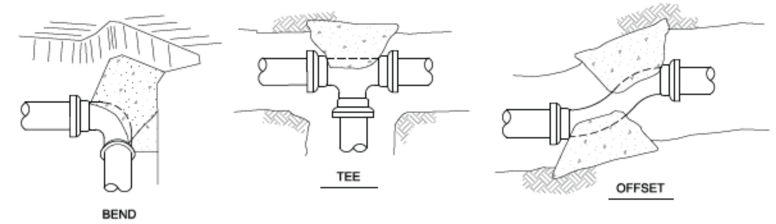
SCALE: AS SHOWN
JOB NO. 2719-02
RELEASE 4
OCT. 2010

REGISTERED PROFESSIONAL ENGINEER
No. 26388
Exp. 3-31-11
CIVIL
STATE OF CALIFORNIA

IMPROVEMENT PLANS FOR CONSTRUCTION OF
WATERFALL GULCH TRANSMISSION MAIN
STATE HIGHWAY 20 TO BRUSH CREEK ROAD
FORT BRAGG, CALIFORNIA

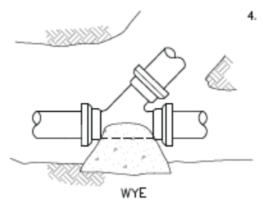
STANDARD DETAILS

KASL CONSULTING ENGINEERS
7777 Greenback Lane
Suite 104
Citrus Heights, CA 95610
Tel. (916) 722-1800
Fax (916) 722-4595
CIVIL - WATER RESOURCES - SURVEYING



TYPICAL CONC. BLOCKING

SHOWN IN PERSPECTIVE



NOTES:

1. SAFE BEARING LOAD OF SOIL FOR HORIZONTAL THRUST SHALL NOT BE EXCEEDED.
2. CONCRETE BLOCKING, CAST-IN-PLACE, TO EXTEND FROM BELLS OF FITTINGS TO UNDISTURBED SOIL AND ENTIRE BEARING AREA MUST BE AGAINST UNDISTURBED SOIL.
3. IN USING THE THRUST BLOCKING TABLE BELOW, ASSUME 2000 P.S.F. BEARING CAPACITY UNLESS OTHERWISE SHOWN ON THE PLANS. THE DESIGN ENGINEER SHALL SPECIFY THRUST BLOCKING REQUIREMENTS FOR ALL OTHER SOIL BEARING CONDITIONS.
4. FOR PLUGGED LEG(S) OF TEE OR CROSS, USE HARNESS TYPE BLOCKING AS SHOWN ON STD. 516 AND CONCRETE BLOCKING INDICATED IN TABLE BELOW.

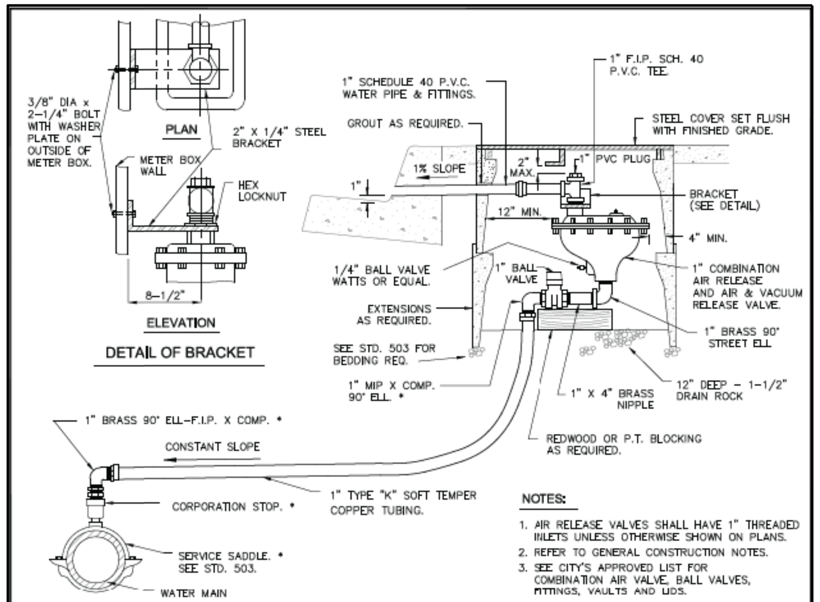
MIN. REQ'D BEARING AREA IN SQ. FT. PER 100 P.S.I. TEST PRESSURE *

PIPE SIZE	SOIL BEARING CAPACITY	HARNESS BLOCKS	TEES & DEAD ENDS	90° BENDS	45° BENDS	22-1/2° BENDS
6"	1000	4	4	6	3	2
	2000	2	2	3	2	1
8"	1000	7	7	10	5	3
	2000	4	4	5	3	2
12"	1000	16	16	22	12	6
	2000	8	8	11	6	3

* MULTIPLY NO. IN TABLE BY TEST PRESSURE & DIVIDE BY 100.

CONCRETE THRUST BLOCK — STD. NO. 520

SCALE: NONE | DRAWN: LMM | CHK: OAB | APPVD: | DATE: APR 2008



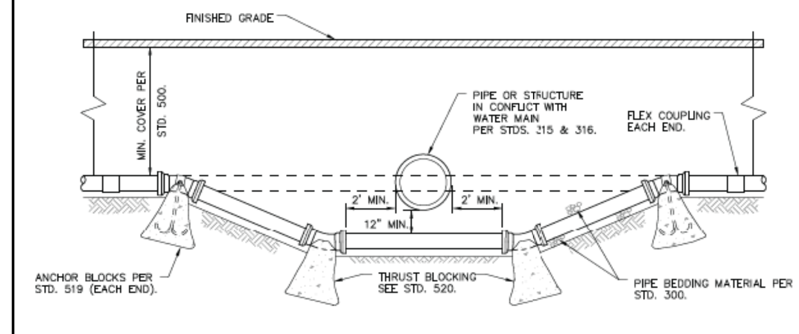
NOTES:

1. AIR RELEASE VALVES SHALL HAVE 1" THREADED INLETS UNLESS OTHERWISE SHOWN ON PLANS.
2. REFER TO GENERAL CONSTRUCTION NOTES.
3. SEE CITY'S APPROVED LIST FOR COMBINATION AIR VALVE, BALL VALVES, FITTINGS, VAULTS AND LIDS.

* - SEE ENGINEER'S APPROVED LIST.

INSTALLATION OF AIR AND VACUUM & AIR RELEASE VALVE — STD. NO. 525

SCALE: NONE | DRAWN: LMM | CHK: OAB | APPVD: | DATE: APR 2008



NOTES:

1. ALL PIPE & FITTINGS SHALL BE DUCTILE IRON & SHALL BE WRAPPED IN POLYETHELENE PER CITY STD. CONSTRUCTION SPECIFICATIONS.
2. ONLY MECHANICAL JOINT FITTINGS WITH RETAINER GLANDS MAY BE USED.
3. ALL BENDS SHALL BE 45° OR 22-1/2° FITTINGS.

WATER MAIN LOWERING DETAIL

WATER MAIN LOWERING DETAIL — STD. NO. 528

SCALE: NONE | DRAWN: LMM | CHK: OAB | APPVD: | DATE: APR 2008

REVISIONS

NO.	DESCRIPTION	DATE	BY

BENCHMARK
FORT BRAGG DATUM

ELEV. ____
DATUM: NAVD 88

SCALE: AS SHOWN
JOB NO. 2719-02

RELEASE 4
OCT. 2010

REGISTERED PROFESSIONAL ENGINEER
STATE OF CALIFORNIA
CIVIL

IMPROVEMENT PLANS FOR CONSTRUCTION OF
WATERFALL GULCH TRANSMISSION MAIN
STATE HIGHWAY 20 TO BRUSH CREEK ROAD
FORT BRAGG, CALIFORNIA

STANDARD DETAILS

CONSULTING
KASL
ENGINEERS
7777 Greenback Lane
Suite 104
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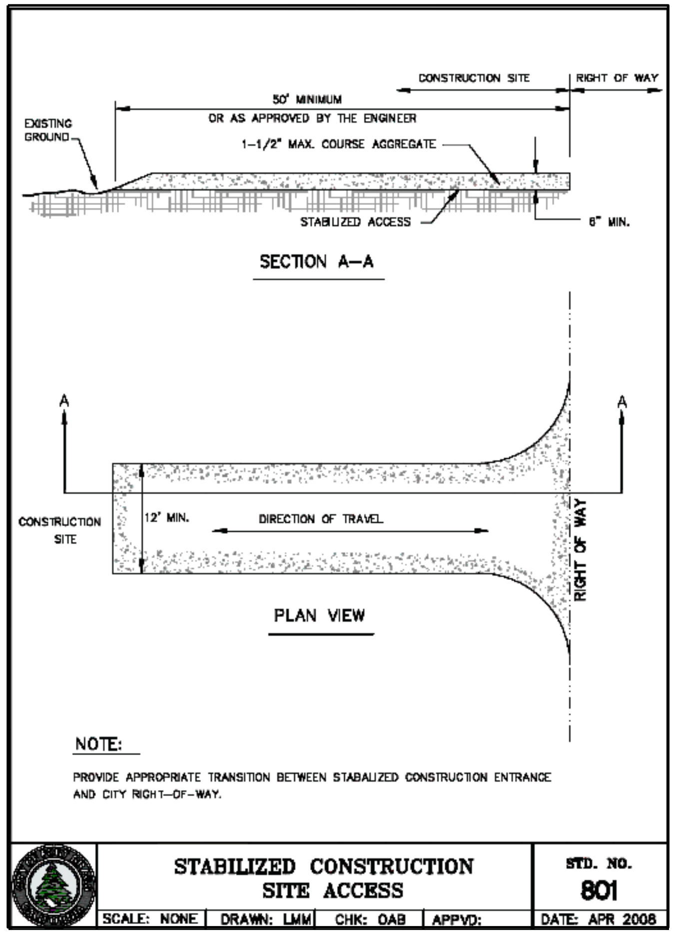
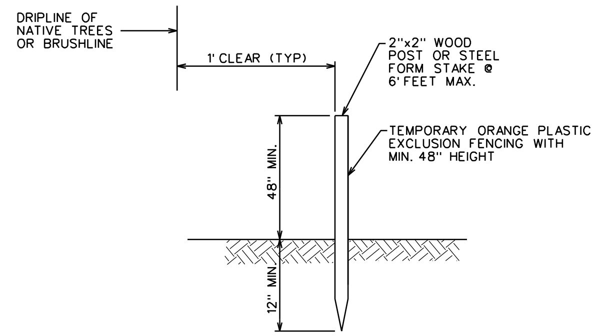


STABILIZED CONSTRUCTION SITE ACCESS 1/11

NO SCALE

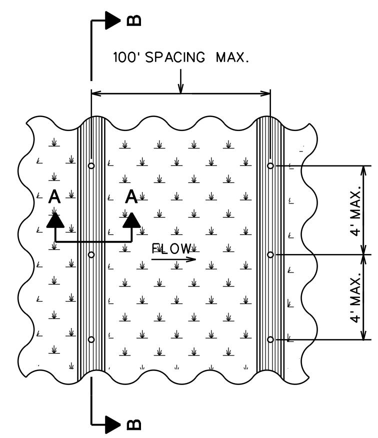


PROTECTIVE BARRIER FENCE INSTALLATION 3/11

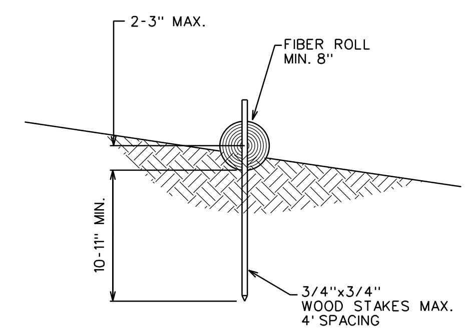
NO SCALE

BEST MANAGEMENT PRACTICES TABLE

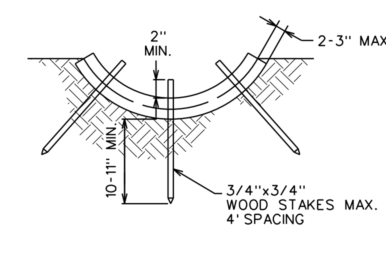
BEST MANAGEMENT PRACTICES	LOCATION	IMPLEMENTATION SCHEDULE	MAINTENANCE SCHEDULE
PRESERVING EXISTING VEGETATION	AROUND PERIMETER OF PROJECT SITE	CONTINUOUS, UNTIL CONSTRUCTION IS COMPLETED	EDUCATE EMPLOYEES & SUBCONTRACTORS REGARDING IMPORTANCE OF MAINTAINING EXISTING VEGETATION TO PREVENT EROSION & FILTER OUT SEDIMENT IN RUNOFF FROM DISTURBED AREAS ON THE CONSTRUCTION SITE. INSPECT SITE PERIMETER MONTHLY TO VERIFY THAT OUTSIDE VEGETATION IS NOT DISTURBED.
PROTECT GRADED AREAS AND SLOPES FROM WASHOUT AND EROSION	THROUGHOUT PROJECT SITE	DURING WET SEASON	INSPECT GRADED AREAS AND SLOPES ON AT LEAST A MONTHLY BASIS TO CHECK FOR EROSION. REGRADE TRIBUTARY AREAS OR INSTALL STRAW BALE OR SAND BAG DIKES AS NECESSARY TO PREVENT EROSION.
STABILIZED CONSTRUCTION SITE ACCESS	ENTRANCES TO SITE FROM PUBLIC ROADWAYS	CONTINUOUS, UNTIL ENTRANCES & ONSITE ROADWAYS ARE PAVED	INSPECT AT THE BEGINNING OF WET SEASON & ON AT LEAST A MONTHLY BASIS THEREAFTER. ADD AGGREGATE BASE MATERIAL WHENEVER NECESSARY TO PREVENT SEDIMENT FROM BEING TRACKED INTO PUBLIC STREET
WIND EROSION CONTROL PRACTICES	WHENEVER NECESSARY THROUGH-OUT PROJECT SITE	CONTINUOUS UNTIL GRADING IS COMPLETED AND SOILS HAVE STABILIZED	INSPECT SITE DURING WINDY CONDITIONS TO IDENTIFY AREAS WHERE WIND EROSION IS OCCURRING & ABATE EROSION AS NECESSARY
GOOD HOUSEKEEPING MEASURES	THROUGHOUT PROJECT SITE	CONTINUOUS UNTIL CONSTRUCTION IS COMPLETED	INSPECT SITE ON AT LEAST A MONTHLY BASIS SO AS TO VERIFY GOOD HOUSEKEEPING PRACTICES ARE BEING IMPLEMENTED
PROPER CONSTRUCTION MATERIAL STORAGE	THROUGHOUT PROJECT SITE	CONTINUOUS UNTIL CONSTRUCTION IS COMPLETED	INSPECT SITE ON AT LEAST A MONTHLY BASIS SO AS TO VERIFY THAT CONSTRUCTION MATERIALS ARE BEING STORED IN A MANNER WHICH COULD NOT CAUSE STORM WATER POLLUTION
PROPER CONSTRUCTION WASTE STORAGE AND DISPOSAL	THROUGHOUT PROJECT SITE	CONTINUOUS UNTIL CONSTRUCTION IS COMPLETED	INSPECT SITE ON AT LEAST A WEEKLY BASIS SO AS TO ASSURE WASTE IS STORED PROPERLY & DISPOSED OF AT A LEGAL DISPOSAL SITE
SPILL CLEANUP	MATERIAL HANDLING AREAS	IMMEDIATELY AT TIME OF SPILL	INSPECT MATERIAL HANDLING AREAS ON AT LEAST A MONTHLY BASIS TO VERIFY PROPER SPILL CLEANUP



TYPICAL FIBER ROLL INSTALLATION



SECTION A-A



SECTION B-B

NOTES:
1. INSTALL FIBER ROLLS IN A ROW ALONG A LEVEL CONTOUR.
2. FIBER ROLLS SHALL BE OVERLAPPED AT THE JOINTS.

FIBER ROLLS 2/11

NO SCALE

EROSION CONTROL NOTES:

1. IT SHALL BE THE RESPONSIBILITY OF THE DEVELOPER TO PREVENT DISCHARGE OF SEDIMENT FROM THE SITE IN QUANTITIES GREATER THAN BEFORE GRADING OCCURED, TO ANY WATERCOURSE, DRAINAGE SYSTEM, OR ADJACENT PROPERTY AND TO PROTECT WATERCOURSES AND ADJACENT PROPERTIES FROM DAMAGE BY EROSION, FLOODING, OR DEPOSITION WHICH MAY RESULT FROM THE GRADING.
2. ALL AREAS WHERE GRADING HAS BEEN COMPLETED BETWEEN APRIL 1 AND OCTOBER 15, SHOULD BE PLANTED BY NOVEMBER 1. GRADED AREAS COMPLETED AT ALL OTHER TIMES OF THE YEAR SHALL BE PLANTED WITHIN FIFTEEN (15) DAYS OF COMPLETION. IF REVEGETATION IS INFEASIBLE OR CANNOT BE EXPECTED TO STABALIZE AN ERODIBLE AREA WITH ASSURANCE DURING ANY PART OF THE RAINY SEASON AND THE UNSTABLE AREA EXCEEDS TWO THOUSAND-FIVE HUNDRED (2,500) SQUARE FEET, ADDITIONAL EROSION AND SEDIMENT CONTROL MEASURES MAY BE REQUIRED AS APPROPRIATE TO PREVENT INCREASED SEDIMENT DISCHARGE.
3. SEED - SEED SHALL BE OF A QUALITY WHICH HAS A MINIMUM PURE LIVE SEED CONTENT OF 80% (% PURITY x % GERMINATION)
4. SEEDING PREPARATION - THE ENTIRE AREA TO BE SEEDED SHALL BE SMOOTH AND SHALL CONFORM TO THE DESIGN GRADES (IF GRADING IS COMPLETE) BEFORE SEEDBED PREPARATION IS BEGUN.
5. ANY DEBRIS WHICH WOULD INTERFERE WITH SEEDING OPERATIONS, GROWTH OR MAINTENANCE OF THE VEGETATIVE COVER SHALL BE REMOVED. SEED AREAS SHALL BE FIRM AND ROUGHENED BY SCARIFYING, DISKING, HARROWING, CHISELING, OR OTHERWISE WORKED TO A DEPTH OF TWO TO FOUR INCHES (2"-4"). NO IMPLEMENT SHALL BE USED THAT WILL CREATE A DOWNWARD MOVEMENT OF SOIL OR CLODS ON SLOPING AREAS.
6. SEEDING - SEED SHALL BE BROADCAST BY HAND, MECHANICAL HAND SEEDER, HYDROSEEDER OR OTHER APPROVED EQUIPMENT. SEED SHALL HAVE A SOIL COVER OF NOT MORE THAN ONE-HALF (1/2) INCH.
7. FERTILIZER - COMMERCIAL FERTILIZER SHALL BE AMMONIUM PHOSPHATE AND CONTAIN A MINIMUM OF 16% NITROGEN, 20% PHOSPHORUS, AND 0% POTASH, UNIFORM IN COMPOSITION, DRY AND FREE FLOWING, PELLETED OR GRANULAR. FERTILIZER SHALL BE PROVIDED WHENEVER TOPSOIL IS NOT REPLACED OVER THE GRADED AREA.
8. MULCH - MULCH SHALL BE EITHER STRAW, WOOD FIBER MULCH OR OTHER ACCEPTABLE MATERIAL. STRAW SHALL BE NEW STRAW DERIVED FROM RICE, WHEAT, OATS, OR BARLEY, AND BE FREE OF MOLD AND NOXIOUS WEED SEED. STRAW SHALL BE FURNISHED IN AIR DRY BALES.
9. MULCHING - AT THE OPTION OF THE CONSULTANT ENGINEER MULCH COVERING MAY BE PROVIDED IN ADDITION TO OR IN LIEU SEEDING. MULCHING SHALL OCCUR WITH OR FOLLOW IMMEDIATELY AFTER SEEDING WHERE APPLICABLE.1. STRAW MULCH SHALL BE APPLIED AT A RATE OF TWO (2) TONS PER ACRE. THE MULCH SHALL BE APPLIED BY HAND OR HAND BLOWER, OR OTHER SUITABLE EQUIPMENT. IF STRAW IS APPLIED WITH A BLOWER, IT SHALL NOT BE CHOPPED IN LENGTHS LESS THAN SIX (6) INCHES.

EARTHWORK NOTES:

1. ALL EXCAVATION, EMBANKMENT, AND BACKFILL SHALL CONFORM TO THE PROVISIONS IN SECTION 19, "EARTHWORK" OF THE STATE STANDARD SPECIFICATIONS.
2. CLEARING AND GRUBBING SHALL CONFORM TO THE PROVISIONS OF SECTION 16 OF THE STATE STANDARD SPECIFICATIONS.

DUST CONTROL NOTES:

1. DUST CONTROL SHALL CONSIST OF APPLYING WATER OR DUST PALLIATIVE TO ALLEVIATE OR PREVENT DUST NUISANCE RESULTING FROM THE CONTRACTOR'S OPERATIONS, EITHER WITHIN OR OUTSIDE THE WORK RIGHT-OF-WAY.
2. DUST CONTROL SHALL BE PERFORMED BY THE CONTRACTOR AT ANY TIME DUST, RESULTING FROM THE CONTRACTOR'S OPERATIONS, BECOMES A NUISANCE OR VISUAL IMPEDIMENT, OR AS DIRECTED BY YUBA COUNTY. FAILURE TO ADEQUATELY CONTROL DUST WILL BE CAUSE FOR YUBA COUNTY TO DIRECT THE CONTRACTOR TO SUSPEND OPERATIONS OR FOR YUBA COUNTY TO PERFORM SUCH ACTIVITY WITH ALL COSTS TO BE BORNE BY THE CONTRACTOR.
3. THE APPLICATION OF WATER FOR DUST CONTROL MAY BE PERFORMED BY THE CONTRACTOR FOR THE CONTRACTOR'S CONVENIENCE. WATER USED IN CONSTRUCTION SHALL CONFORM TO SECTION 17, "WATERING", OF THE STATE SPECIFICATIONS.
4. DUST CONTROL MEASURES ARE TO BE PROVIDED DURING ANY GRADING OR EARTH MOVING ACTIVITIES AS WELL AS ON ANY UNSTABILIZED, EXPOSED SOILS.
5. THE TYPICAL WATER TRUCK APPLICATION RATE IS 1/4-GALLON PER SQUARE YARD, EVERY 30 MINUTES, AS REQUIRED.
6. SATURATION OF SOILS SHOULD BE AVOIDED TO PREVENT ADDITIONAL PROBLEMS SUCH AS TRACKING AND NON-STORM WATER DISCHARGES.

REVISIONS			
NO.	DESCRIPTION	DATE	BY

BENCHMARK
FORT BRAGG DATUM

ELEV.
DATUM: NAVD 88

RELEASE 4
OCT. 2010

SCALE: N.A.
JOB NO. 2719-02

IMPROVEMENT PLANS FOR CONSTRUCTION OF
WATERFALL GULCH TRANSMISSION MAIN
STATE HIGHWAY 20 TO BRUSH CREEK ROAD
FORT BRAGG, CALIFORNIA

EROSION CONTROL NOTES & DETAILS

CONSULTING KASL ENGINEERS
7777 Greenback Lane
Suite 104
Citrus Heights, CA 95610
Tel. (916) 722-1800
Fax (916) 722-4595
CIVIL - WATER RESOURCES - SURVEYING

TECHNICAL SPECIFICATIONS

WATERFALL GULCH TRANSMISSION MAIN
STATE HIGHWAY 20 TO BRUSH CREEK ROAD
CITY OF FORT BRAGG, CALIFORNIA

STANDARD SPECIFICATIONS

The City of Fort Bragg Standard Specifications (City Standard Specifications) and Standard Plans (City Standard Plans), dated April 2008 and these Technical Specifications shall control all work to be done under this contract. Copies of the City Standard Specifications and City Standard Plans may be obtained from the City of Fort Bragg, 416 North Franklin Street, Fort Bragg, California 95437.

Improvements constructed under this Contract shall also be constructed in accordance with the most recent version of the Standard Specifications of the State of California, Department of Transportation, Division of Highways, which specifications are hereinafter referred to as the State Standard Specifications, and in accordance with the following modifications and revisions.

Whenever in the State Standard Specifications the terms State of California, Department of Transportation, Director, Division of Highways or Engineer are used, the following terms shall be understood and interpreted to mean and refer to such substituted terms as follows:

> For State of California substitute City of Fort Bragg
>
> For Department--The Public Works Department of the City of Fort Bragg
>
> For Director--The City Engineer of the City of Fort Bragg
>
> For Division of Highways--The Public Works Department of the City of Fort Bragg
>
> For Engineer--The City Engineer, acting either directly or through properly authorized agents, such agents acting within the scope of the particular duties entrusted to them.

BEGINNING OF WORK

The Contractor is advised that no field construction work may commence and the counting of working days shall not begin until Notice to Proceed is issued by the City. Work that does not involve field construction such as pre-construction meetings, creation of progress schedules, preparation of Traffic Control Plan, preparation of Erosion and Sediment Control Plan etc., may occur prior to the counting of working days.

ORDER OF WORK

Order of Work shall conform to the provisions in Section 5-1.05, “Order or Work”, of the State Standard Specifications and these Technical Specifications.

Attention is directed to the “Notifications” section of these Technical Specifications regarding notification to the Project Inspector and the affected residences and businesses.

As directed by the City, the Contractor shall submit and obtain approval for shop drawings and submittals prior to beginning any work. Shop drawings shall be prepared and submitted in accordance with Section 1-1.08 of the City Standard Specifications.

Payment

Full compensation for conforming to the requirements of this section shall be considered as included in the Contract prices paid for the various items of work involved and no additional compensation will be allowed.

TIME OF COMPLETION

The Time of Completion for this Contract shall be ______________ (_____) calendar days.

LIQUIDATED DAMAGES

The Liquidated Damages for this contract shall be the sum of ________ hundred dollars ($_____) per day.

NOTIFICATION

The Contractor shall notify the City’s Engineer or the City’s Project Inspector of any work to be performed under this Contract on any given work day either on the afternoon of the prior working day or before 8:30 a.m. on the given working day. Any work completed for which the Engineer or Project Inspector has not received prior notification of its scheduling MAY NOT BE ACCEPTED FOR PAYMENT.

The Contractor shall notify residents of impending construction activity 3 calendar days prior to doing any work in front of their home or within pipeline easement areas on privately owned property. The Contractor’s notification shall describe and explain what work will be taking place and the potential impacts of this work on the affected residents.

The written notifications shall be placed on doors and shall indicate the Contractor’s name and phone number, type of work, day(s) and time when work will occur. Notice shall be reviewed and approved by the City prior to being distributed.

Payment

Full compensation for conforming to the requirements of this section shall be considered as included in the Contract prices paid for the various items of work involved and no additional compensation will be allowed.

PROGRESS SCHEDULE

A preliminary baseline construction schedule shall be prepared by the Contractor and submitted at the Preconstruction Meeting. The Progress Schedule shall conform to Section 8-1.04 Progress Schedule of the State Standard Specifications and to the requirements of the City.

Payment

Full compensation for conforming to the requirements of this section shall be considered as included in the Contract prices paid for the various items of work involved and no additional compensation will be allowed.

UNAVOIDABLE DELAYS

The Contractor may be granted an extension of Contract time for delays that are determined to be beyond the control of the Contractor, impact a controlling item of work and could not be prevented by the exercise of care, prudence, foresight and diligence. Material shortages and delays in utility company relocations may be classified as unavoidable if the Contractor produces satisfactory evidence of acting in a timely manner.

No extension of time will be granted for a delay caused by a shortage of materials unless the Contractor furnishes to the City documentary proof that he has made every effort to obtain such materials from all known sources, within reasonable reach of the work in a diligent and timely manner. The documentary proof shall indicate that the inability to obtain such materials, when originally planned, did in fact cause a delay in final completion of the entire work which could not be compensated for by revising, the sequence of the Contractor's operations. The term "Shortage of Materials" as used in this section, shall not apply to materials, articles, parts, or equipment that are processed, made, constructed, fabricated or manufactured to meet the specific requirements of the Contract. Only the physical shortage of material will be considered under these provisions as a cause for extension of time. Delays in obtaining materials due to priority in filling orders will not constitute a shortage of materials.

HOURS OF WORK

The Contractor shall restrict hours of work to weekday period between 7:00 a.m. and 6:00 p.m.

No work will be allowed on weekends or designated legal holidays without prior written approval of the City.

Designated legal holidays are: January 1st, the third Monday in January, the third Monday in February, the last Monday in May, July 4th, the first Monday in September, November 11th, Thanksgiving Day, the day following Thanksgiving and December 25th. When a designated legal holiday falls on a Sunday, the following Monday shall be a designated legal holiday. When a designated holiday falls on a Saturday, the preceding Friday shall be a designated legal holiday.

Inspection service expenses incurred by the City resulting from any overtime work, including work over 8 hours per day or approved weekend or holiday work shall be reimbursed by the Contractor.

SAFETY

The Contractor shall at all times conduct the Work under this Contract in accordance with Construction Safety Orders of the Division of Industrial Safety, State of California, to insure the least possible obstruction to traffic and inconvenience to the general public and adequate protection of persons and property in the vicinity of the work.

No access way shall be closed to the public without first obtaining permission of the City.

Should the Contractor fail to provide public safety as specified or, if in the opinion of the City, the warning devices furnished by the Contractor are not adequate, the City may place warning lights or barricades or take any necessary action to protect or warn the public of any dangerous condition connected with the Contractor's operations and the Contractor shall be liable to the City for all costs incurred plus 100%.

Nothing in this section shall be construed to impose tort liability on the City or Engineer.

Payment

Full compensation for conforming to the requirements of this section shall be considered as included in the Contract prices paid for the various items of work involved and no additional compensation will be allowed.

COOPERATION

The Contractor's attention is directed to Sections 7-1.14 "Cooperation", and 8-1.10, "Utility and Non-Highway Facilities", of the State Standard Specifications and these Technical Specifications

Payment

Full compensation for conforming to the requirements of this section shall be considered as included in the Contract prices paid for the various items of work involved and no additional compensation will be allowed.

OBSTRUCTIONS

The Contractor's attention is directed to Sections 8-1.10, "Utility and Non-Highway Facilities", and 15, "Existing Highway Facilities", of the State Standard Specifications and these Technical Specifications.

There are overhead and underground power, telephone, and television cable facilities, underground private sewers, underground gas services, and underground water mains and laterals within the area in which construction is to be performed. In the area of work the existing Waterfall Gulch Transmission Main is to be replaced with the new water main to be placed as part of this Contract. The existing Waterfall Gulch Main placed within the limits of work is to be removed from service by the City before construction of the new water main. The existing main is an Asbestos Cement Pipe (ACP) and is to be abandoned in place. Should the Contractor remove or expose the existing ACP during construction of the replacement main he shall notify the City to coordinate the safe handling and disposal of the existing asbestos cement pipe material.

Other than the existing Waterfall Gulch water main, there are no known public water main or public sewer mains in the Project area. There may, however, be privately owned water, sewer, storm drain, or gas mains and laterals in the Project area.

The Contractor shall notify the City and Underground Service Alert for identification of subsurface installations at least 2 working days, but not more than 14 calendar days, prior to performing any excavation or other work close to any underground pipeline, conduit, duct, wire or other structure. To contact Underground Service Alert, call toll free (800) 642-2444.

Upon notification, agencies having facilities in the area of the proposed excavation will mark their locations in the field using USA standard colors and codes to identify the facility.

The Contractor will be required to work around public and private utility facilities and other improvements that are to remain in place within the construction area and will be held liable to the owners of such facilities for interference with service resulting from the Contractor's operations. The Contractor shall take all necessary measures to avoid damage to existing surface and underground utility facilities in the Project area. No error or omission of utility markouts shall be constructed to relieve the Contractor from his responsibility to protect underground pipes, conduits, cables or other structures. The Contractor shall indemnify the City and hold it harmless from any and all claims, demands or liability made or asserted by any person or entity on account of or in connection with any damage to such surface or underground facilities caused by the Contractor or any of his agents or subcontractors.

Payment

Full compensation for conforming to the requirements of this section shall be considered as included in the Contract prices paid for the various items of work involved and no additional compensation will be allowed.

WORK ON PRIVATE PROPERTY

The Contractor shall protect private improvements from damage. On-site private improvements may include, but are not limited to, trees, shrubbery, lawns, irrigation facilities, structures, septic tanks, leach fields, wells, propane tanks, mailboxes, pavement, curbing, and drainage facilities. If such objects are damaged, they shall be replaced, repaired and or restored at the Contractor's expense, to a condition as good or better as when the Contractor entered upon the property, as determined by the City.

During the contract period, the Contractor will not restrict access to or from private residential driveways. The Contractor, under circumstances within his control, will complete construction in a timely and diligent manner.

Work is to be constructed within existing pipeline easements, public roadways and public utility easements except as otherwise noted on the Plans.

The Contractor shall be responsible for repairing, replacing, or modifying all landscape and irrigation systems within the limits of Work that are damaged, capped, or removed during construction. Damage shall include all that is caused as a result of any and all work associated with the contract. All repairs to both landscaping and irrigation system shall be done in a manner equal to or better than the previously existing conditions. If irrigation systems are damaged during trenching, or other construction activities, the Contractor shall repair the damage within two (2) calendar days in order to maintain full operation of the system. Any loss and/or subsequent replacement of plant material due to damage of the irrigation system or the neglect to repair it promptly shall be the sole responsibility of the Contractor. Landscape replacement or repair shall be completed as soon as it will not be damaged by further construction activities.

Payment

Full compensation for conforming to the requirements of this section shall be considered as included in the Contract prices paid for the various items of work involved and no additional compensation will be allowed.

WATER FOR CONSTRUCTION AND DUST CONTROL

The Contractor shall be responsible for providing all water necessary for construction and dust control. Water is available from the City at no charge. If the Contractor proposes to use City water for construction and dust control, the Contractor shall request from the City the location of the fire hydrant acceptable for obtaining water. The City will confirm the location in writing and the identified fire hydrant shall be the only hydrant that the Contractor will be allowed to use.

Payment

Full compensation for conforming to the requirements of this section shall be considered as included in the Contract prices paid for the various items of work involved and no additional compensation will be allowed.

MAINTAINING TRAFFIC

The Contractor’s attention is directed to Section 7-1.08, "Public Convenience," 7-1.09, "Public Safety," and Section 12 "Construction Area Traffic Control Devices," of the State Standard Specifications. Nothing in these Technical Specifications shall be constructed as relieving the Contractor from his responsibilities as provided in said Section 7-1.09.

The Contractor shall provide the City with a traffic control plan at least 2 weeks prior to the start of construction for review and approval in accordance with these Technical Specifications.

The Contractor will be required to maintain vehicle access to homes and other properties within the Project area. Emergency vehicle access shall be maintained throughout the Project limits at all times.

Lane closures shall conform to these Technical Specifications.

Personal vehicles of the Contractor's employees shall not be parked on the traveled way.

The Contractor shall notify the City of his intent to begin work at least 5 days before work is scheduled to begin. The Contractor shall cooperate with local authorities directing traffic through the Project area and the Contractor shall make his own arrangements to keep the working area clear of parked vehicles.

Whenever the Contractor’s vehicles or equipment are parked on the shoulder within 6 feet of a traffic lane, the shoulder area shall be closed with fluorescent traffic cones or portable delineators placed on a taper in advance of the parked vehicles or equipment and along the edge of the pavement at 25-foot intervals to a point not less than 25 feet past the last vehicle or piece of equipment. A minimum of 9 cones or portable delineators shall be used for the taper. A C23 (Road Work Ahead) or C24 (Shoulder Work Ahead) sign shall be mounted on a telescoping flag tree with flags. The flag tree shall be placed where directed by the City.

When leaving a work area and entering a roadway carrying public traffic, the Contractor's equipment, whether empty or loaded, shall in all cases yield to public traffic.

A minimum of one traffic lane, not less than 10 feet wide, shall be open for use by public traffic at all times. When construction operations are not actively in progress, not less than two such lanes shall be open to public traffic.

Minor deviations from the requirements of these Technical Specifications concerning hours of work which do not significantly change the cost of the Work may be permitted upon the written request of the Contractor if in the opinion of the City public traffic will be better served and the work expedited. Such deviations shall not be adopted until the City has issued written approval. All other modifications will be made by contract change order.

Backfilled trenches in existing pavement shall be temporarily paved and maintained with asphalt concrete, or permanently paved (consistent with the existing pavement section) with asphalt concrete, before allowing traffic on the trenches.

Payment

Full compensation for conforming to the requirements of this section shall be considered as included in Contract lump sum price paid for Traffic Control and no additional compensation will be allowed.

TRAFFIC CONTROL PLAN

The Contractor shall submit a Traffic Control Plan for all phases of construction prior to any work that impacts traffic (vehicular, pedestrian, bicycle).

The Contractor's attention is directed to Section 7-1.08 "Public Convenience", Section 7-1.09 "Public Safety", and Section 12 "Construction Area Traffic Control Devices" of the State Standard Specifications. The Contractor shall make all reasonable effort to avoid traffic delays and shall have sufficient flaggers available to respond to emergency situations. The Contractor shall provide flaggers at all times that only one lane of traffic is open, and as required to facilitate traffic movements in and around work zone, including key intersections and driveways of residences that will be affected by road closure.

At the end of each day, the Contractor shall open all lanes of traffic using AC cold patches and steel plates as necessary or as directed by the City.

The Contractor shall use traffic cones, delineators and signs that are clean, functional, uniform, and highly visible to the public. If the City determines that the cones and/or signs have diminished visibility or function, the Contractor shall replace the cones and/or signs with new ones at no extra cost.

The Traffic Control Plan shall be prepared on 11" x 17" sheet(s) of paper which contains only information specifically related to work zone traffic control. The Traffic Control Plan shall be submitted for review by the City at least two weeks prior to the scheduled beginning of Work.

The Traffic Control Plan shall contain a title block which contains the Contractor's name, address, phone number, Project superintendent's name, contract name, dates and hours traffic control will be in effect, and a space for review acknowledgment.

The content of the Traffic Control Plan shall include, but is not limited to, the following:

A. Location and limits of the work zone.

B. Dimensions of lanes affected by traffic control that will be open to traffic.

C. Signing, cone placement and other methods of delineation and reference to appropriate City or Caltrans standard.

D. Dimensioned location of signs and cone tapers.

E. Side streets and driveways affected by construction; the Traffic Control Plan will show how side street and driveway traffic will be controlled.

F. How two-way traffic will be maintained around the zones that are closed to through traffic.

No work except for installation of Project identification signs will be allowed to commence prior to the City's approval of the Traffic Control Plan.

If any component in the traffic control system is damaged, displaced or ceases to operate or function as specified, from any cause, during the progress of the Work, the Contractor shall immediately repair said component to its original condition or replace said component and shall restore the component to its original location.

Payment

Full compensation for conforming to the requirements of this section shall be considered as included in the Contract lump sum price for Traffic Control and no additional compensation will be allowed.

SHORING AND BRACING

In accordance with the latest requirements of the California Occupational Safety and Health Act (Cal-OSHA) and all such similar legislation, the Contractor shall submit to the City for reference in advance of excavation a Cal-OSHA approved detailed plan showing the design, shoring, bracing, sloping or other provision to be made for work or protection from the hazard of caving ground during the excavation of trench or trenches which exceed 5 feet in depth. If such plan varies from the shoring system standards, the plan shall be prepared by a Registered Civil or Structural Engineer.

The plan shall be kept on the job site at all times. The Contractor shall have a competent person, conversant with the plan on site at all times.

Nothing in this section shall be deemed to allow the use of shoring, sloping or protective system less effective than that required by the Cal-OSHA.

Nothing in this section shall be construed to impose tort liability on the City.

Payment

Full compensation for conforming to the requirements of this section shall be considered as included in the unit price for Transmission Main and no additional compensation will be allowed.

CLEAN UP

The Contractor's attention is directed to Section 4-1.02 of the State Standard Specifications.

Before final inspection of the Work, the Contractor shall clean the construction site and all ground occupied by them in connection with the Work, of all rubbish, excess materials, false work, temporary structures and equipment. All parts of the Work shall be left in a neat and presentable condition.

Nothing herein shall require the contractor to remove warning, regulatory and guide signs prior to formal acceptance by the City.

Payment

Full compensation for conforming to the requirements of this section shall be considered as included in the Contract prices paid for the various items of Work involved and no additional compensation will be allowed.

CLEARING AND GRUBBING

Clearing and Grubbing shall conform to Section 16 of the City Standard Specifications. This work shall include the removal of all objectionable material within the limits of the existing pipeline easement in Pipeline Segment 2 and along the shoulder of Thomas Lane and Brush Creek Road in Pipeline Segment 1. Clearing and grubbing shall be completed in advance of trenching operations and in accordance with the requirements of these Technical Specifications. The Contractor shall remove only those trees within the existing pipeline easement shown on the Plans to be removed. Existing trees located outside of the limits of the pipeline easement and located outside the limits of the pipeline construction shall not be removed.

Where trees and shrubs are to be removed roots and other objectionable material shall be removed to the full depth and width of the pipeline trench.

Burning of combustible material removed with the Contractor's clearing and grubbing shall not be allowed. Unsuitable and surplus material removed with the Contractor's clearing and grubbing operations shall become the property of the Contractor, shall be removed from the construction site and properly disposed.

All existing street designations and traffic control signs and posts within the limits of Work shall be carefully removed, cleaned of excess earthen material and delivered to the City Corporation Yard. The Contractor shall provide temporary traffic control in the Project area in accordance with the approved Traffic Control Plan

All mail boxes which must be relocated to construct the pipeline improvements shall be moved and reset as directed by the property owner.

The removal and repair of existing sprinkler or irrigation systems, if necessary, shall be conducted in accordance with “Work on Private Property” previously specified in these Technical Specifications.

The Contractor shall comply with all requirements of tree preservation as indicated on the Plans and as further specified in the “Protective Fencing” section of these Technical Specifications.

All trees to be removed are shown on the Plans and shall be clearly marked in the field by the City. The City’s Inspector shall review the trees to be removed with the Contractor prior to removal.

Payment

The Contract Lump Sum for Clearing and Grubbing shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals involved and for the proper removal and disposal of surplus material, for the preservation of private property and vegetation located outside the limits of existing pipeline limits and limits of work and for completing all clearing and grubbing work involved and no additional compensation will be allowed.

EROSION CONTROL

Erosion and Sediment Control work shall conform to the requirements of the City, to the erosion and sediment control details included on the Plans and to the requirements of the Storm Water Pollution Prevention Plan (SWPPP) prepared, by others, for this Project. The Contractor shall minimize erosion and sediment during all aspects of the Project.

All erosion control measures shall be installed and in place between October 1 and April 30. Installation shall comply with the details shown on the Plans and the SWPPP prepared for this Project. The Contractor shall be responsible for maintaining project erosion control measures throughout the Contract period as detailed in the maintenance schedule included in the erosion control plans approved for this Project.

All non-pavement areas of the Project which have been graded, trenched or disturbed shall be seeded for erosion control as detailed in the Plans approved for this Project. All clearing, trenching, earth moving, backfilling and grading operations of this Project shall be completed during dry weather between May 1 and October 1 unless otherwise permitted by the City.

Payment

The Contract Lump Sum for Erosion Control shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals involved and for maintaining approved erosion control measures throughout the Contract period and no additional compensation will be allowed.

PROTECTIVE FENCING

Protective fencing shall be installed along the limits of the existing pipeline easement within Pipeline Segment 2 and along the brush line or tree line adjacent to the shoulder of Thomas Lane and Brush Creek Road within Pipeline Segment 1. Protective barrier fencing shall be installed as shown on the Plans and shall include 2” x 2” wood post or steel form stakes placed at 6 foot intervals. The wood posts or stakes shall support 48 inch high orange plastic exclusion fencing approved by the City.

The Contractor shall coordinate the installation of the protective fencing with property owners. The installation of the protective fencing shall not impede access to properties by residents or impede access by emergency service providers. The Contractor shall maintain the protective fencing throughout the Contract period.

Payment

The Contract unit price paid for Protective Fencing shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals involved and for maintaining and reinstalling protective fencing, as necessary, throughout the construction period and no additional compensation will be allowed.

REMOVE AND REPLACE EXISTING FENCING

The scope of this work shall include removal and replacement of existing property line fences which interfere with the construction of the pipeline improvements. Removal of existing fences are shown on the Plans and shall be coordinated with property owner(s). Where existing fencing is removed the Contractor shall install temporary fencing which shall remain in place throughout construction of improvements. The Contractor shall maintain temporary fencing, as required, throughout the Contract period. At the completion of construction the Contractor shall replace the fence removed with new fence material and fence supports equal or better quality than the fence removed. Fence replacement shall be completed as approved by the City and to the satisfaction of the property owner(s).

Payment

The Contract unit price paid for Remove and Replace Fencing shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals involved and for the installation and maintenance of suitable temporary fencing throughout the construction period and no additional compensation will be allowed.

CONNECT TO EXISTING PIPELINE

The scope of this work shall include furnishing and placement of all fittings and connections required to connect to the existing pipeline at the end of Pipeline Segment 1 (connection to Summers Lane Pipeline) and either at the beginning of Pipeline Segment 1 (Pipeline Station 18 + 35) if only the Segment 1 Pipeline is constructed or at the beginning of Pipeline Segment 2 (Pipeline Station 1 + 00) if both Pipeline Segment 1 and Pipeline Segment 2 are constructed. New pipeline connection material shall conform to the City Standard Specifications. Installation shall conform to the City Standard Specifications, the City Standard Plans, these Technical Specifications and to the Plans approved for this Project.

The flexijoint connections installed at each location shall be Romac Industries, Flange by Flange or Flange by Mechanical Joint. The flexijoint shall be a flexible ductile iron fitting designed to compensate for expansion, contraction, rotation and settlement at the pipeline connection. The casing, ball and sleeve shall be ductile iron meeting or exceeding ASTM A536, Grade 65-45-12. All external bolts and nuts shall be 304 Stainless Steel. The entire fitting shall be lined and coated with fusion bonded epoxy applied and tested in accordance with ASTM C213.

The entire pipeline connection shall be protected with a polyethylene sleeve, minimum 8 mils thick. The polyethylene sleeve shall be placed after the pipeline connection is installed and banded on each end to secure the connection ends to the pipeline.

The pipeline connection shall be bedded and backfilled in accordance with City Standard Specifications and City Standard Plans.

Payment

The Contract price paid for each Connect to Existing Pipeline shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals and for furnishing and placement of polyethylene encasement, bedding and backfill in accordance with City Standard Specifications, City Standard Plans, these Technical Specifications and as directed by the City and no additional compensation will be allowed.

GATE VALVE AND VALVE BOX

The scope of this work shall include the furnishing and installation of gate valves and valve box with riser. All materials shall conform to the City Standard Specifications Section 99-1.05 and City Standard Drawing No. 501. Gate valves shall be resilient seat with non-rising stem conforming to AWWA Standard C-509. Gate valve shall be American Darling, Mueller, Clow, Ford or equal as approved by the City.

All external bolts and nuts shall be 304 Stainless Steel.

Valve extensions shall be installed prior to final inspection by the City. Valve stem extension materials shall conform to City Standard Drawing No. 501. The scope of Work shall include furnishing and installation of valve, precast concrete valve box with cast iron ring and cover, concrete valve collar and valve box riser. Valve box and cover shall be traffic rated Christy G5, VG8 or Quartzite and conform to the City's approved list of materials. Each valve box cover shall be marked "WATER".

Payment

The Contract price paid for each gate valve and valve box shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals and for placement of bedding, backfill operation and testing of gate valve, valve box and valve box cover, valve stem, valve box riser and tracer wire in accordance with City Standard Specifications, City Standard Plans, these Technical Specifications and as directed by the City and no additional compensation will be allowed.

FLUSHING CONNECTION

The scope of this work shall include the furnishing and installation of flushing connection as shown on the Plans and as specified herein. The flushing connection tee installed at the Waterfall Gulch main, the 6 inch diameter gate valve, valve box and riser and the 6 inch diameter ductile iron pipe lead to be furnished and installed as part of the flushing connection shall conform to the City Standard Specifications and City Standard Plans. Gate valve and valve box improvements shall be furnished and installed as previously specified in these Technical Specifications.

The flushing connection hydrant shall be a wharf or post type hydrant similar to Mueller Company 2-1/8" post type or approved equal. The hydrant shall be painted as noted on the Plans. All ductile iron pipe fittings and materials shall be lined and coated with fusion bonded epoxy applied and tested in accordance with ASTM C213. The hydrant shall meet applicable sections of ANSI / AWWA C502 Standard. All external buried bolts and nuts shall be 304 Stainless Steel. The flushing connection shall be installed with concrete thrust block per City Standard Drawing No. 502. The wharf hydrant shall be furnished and installed with suitable flanged fittings to connect the hydrant shoe piece with the 6 inch diameter flushing connection lead. Below ground portions of the flushing connection shall be protected with a polyethylene wrap, minimum 8 mils thick. The polyethylene wrap shall be placed after the flushing connection is installed and shall be securely taped to the connection. The hydrant shall include a threaded 2-1/8" diameter main valve suitable for connection to City of Fort Bragg fire hose supply.

Payment

The Contract price paid for each Flushing Connection shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals involved and for placement of bedding, backfill, operation and testing of the flushing connection in accordance with City Standard Specifications, City Standard Plans, these Technical Specifications and as directed by the City and no additional compensation will be allowed.

FLUSHING DRAIN

The scope of this work shall include the furnishing and installation of flushing drain as shown on the Plans and as specified herein. The flushing drain connection at the Waterfall Gulch main, the 6 inch diameter gate valve, valve box and riser and the ductile iron flushings and pipe shall conform to City Standard Specifications and City Standard

Plans. Gate valve and valve box components shall be furnished and installed as previously specified in these Technical Specifications. The 6 inch diameter rubber check valve drain discharge shall be Tideflex Series 35-1, or equal, as approved by the City. The Contractor shall furnish and install the rubber check valve in accordance with manufacturer's recommendations. At the flushing drain discharge the Contractor shall furnish and install rip rap erosion protection as shown on the Plans.

All ductile iron pipe fittings and pipe materials shall be lined and coated with fusion bonded epoxy applied and coated in accordance with ASTM C213. All external buried nuts and bolts shall be 304 Stainless Steel. The below ground section of the flushing drain shall be protected with a polyethylene wrap minimum 8 mils thick. The polyethylene wrap shall be placed after the flushing drain is installed and securely taped to each end of the buried drain.

Payment

The Contract price paid for each Flushing Drain shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals involved and for placement of bedding, backfill and for the operation and testing of the flushing drain in accordance with City Standard Specifications, City Standard Plans, these Technical Specifications and as directed by the City and no additional compensation will be allowed.

AIR AND VACUUM RELEASE VALVE

The scope of this work shall include the furnishing and installation of low pressure combination air and vacuum release valve (AVRV). The AVRV installation shall include corporation stop connection to the Waterfall Gulch main, 1 inch diameter copper tubing, AVRV connections and valve box as shown on City Standard Drawing No. 525. The Contractor shall furnish and install AVRV materials in accordance with City Standard Specifications.

The AVRV shall be a low pressure type as manufactured by Waterman, APCO, Crispin, Golden Anderson, or approved equal, suitable for the low pressure (less than 20 psi) of the Waterfall Gulch Transmission Main.

The AVRV box and cover shall be traffic rated Christy B36 with 36-6ID cover or Quazite PG 1730 BA12 with PG1730HAR250 cover or approved equal.

Payment

The Contract price paid for each AVRV shall include full compensation for furnishing all labor, materials, tools and equipment and incidentals involved and for placement of bedding, backfill and for operation and testing of the AVRV in accordance with City Standard Specifications, City Standard Plans, these Technical Specifications and as directed by the City and no additional compensation will be allowed.

TRANSMISSION MAIN

The scope of this work shall include the furnishing and installation of 10 inch diameter Polyvinyl Chloride (PVC) C900, Class 235 transmission main as shown on the Plans, as specified in the City Standard Specifications and as further specified herein. Unless otherwise directed by the City the water main shall be installed with 40 inches minimum cover.

Trench excavation shall conform to the requirements of Section 19-1.06 of the City Standard Specifications. Pipe bedding and trench backfill material shall be well graded aggregate material and shall have a minimum sand equivalent of 30. The pipe bedding and backfill material shall conform to City Standard Drawing No. 300 and the following:

	Percent Passing			
	3"	1"	¾"	No. 4
Pipe Bedding	--	100%	95-100%	55-100%
Trench Backfill	100%	--	--	40-100%

Pipe bedding material shall be compacted to not less than 90% relative compaction. For the Segment 1 pipeline constructed in pavement and shoulder areas of Thomas Lane and Brush Creek Road trench backfill shall be compacted to 90% relative compaction. The upper 12 inches of backfill below the roadway structural section shall be Class 2 Aggregate compacted to 95% relative compaction.

In Segment 2 the pipeline placed in unpaved easement areas shall be constructed with trench backfill compacted to 90% relative compaction with the top 30 inches consisting of approved native material with no rocks larger than 3 inches in diameter and compacted to 85% relative compaction.

In place density and relative compaction results may be determined on the basis of individual test sites in lieu of the area concept. Relative compaction testing as determined by ASTM D 2927-81 is amended in accordance with City Standard Specifications, Section 6, and "Control of Materials".

Excess material not used in the backfill of pipeline trenches shall be removed promptly and disposed of by the Contractor at the Contractor's expense.

Imported material proposed for pipe bedding and backfill shall be first tested and approved by the City. All costs associated with material testing shall be paid by the Contractor. Tests shall be made in accordance with:

- Grading — ASTM C114 and C136
- Plasticity Index — ASTM D424
- Sand Equivalent Test — California Test Method 217

The Waterfall Gulch Water Main material shall conform to Section 99 of the City Standard Specifications for PVC Pipe.

The Waterfall Gulch pipeline shall be installed in accordance with City Standard Specifications 99-1.11 and 99-1.12. Hydrostatic testing of the pipeline shall be conduced in accordance with City Standard Specification 99-1.15.

The PVC pipe shall be installed with a Number 10 insulated copper wire laid on top of and along the entire length and extended to the surface at all valves, flushing connections and flushing drains.

Unless otherwise directed by the City chlorination of the Waterfall Gulch Water Main is not required.

Payment

The Contract price paid per lineal foot for Transmission Main shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals involved and for the furnishing and placement of pipeline bedding and backfill material, finish grading and drainage, insulating copper wire, and hydrostatic testing in accordance with City Standard Specifications, City Standard Plans, these Technical Specifications and as directed by the City and no additional compensation will be allowed.

CONTROLLED DENSITY BACKFILL

The scope of this work shall include the trenching and placement of control density backfill (cement slurry) at the location(s) shown on the Plans.

Control density backfill material shall consist of a workable mixture of aggregate, cementitious materials, and water. Prior to delivery to the project site, the Contractor shall submit for approval by the City a mix design and test date that demonstrates that the mix design complies with the following:

- Portland cement shall be Type II, not less than one sack per cubic yard.

- Admixtures, including mineral admixtures (pozzalan), may be used in conformance with Section 90-4, “Admixtures” of the State Standard Specifications. Chemical admixtures containing chlorides in excess of one percent (1%) by mass of admixture, as determined by California Test Method 415, shall not be used. The amount of air-entrainment admixture added shall be a minimum of eight percent (8%) and a maximum of twenty percent (20%),

- Course aggregate shall consist of a well-graded mixture of crushed rock with a maximum size aggregate of three-eighths inch (3/8”). One hundred percent (100%) shall pass the one-half-inch (1/2”) sieve. Not more than thirty percent (30%) shall be retained by the three-eighths inch (3/8”) sieve and not more than twelve percent (12%) shall pass the No. 200 sieve. All material shall be free from organic mater and not contain more alkali, sulfates, or salts than the native materials at the site of work.

The minimum twenty-eight-day (28-day) compressive strength shall be fifty pounds per square inch (50 psi) and a maximum shall be one hundred pounds per square inch (100 psi).

Control density backfill shall be placed where 40 inches of cover can not be achieved. The controlled density backfill shall be placed above the initial backfill material and conformed to the finished surface.

Payment

The Contract price paid per cubic foot of Controlled Density Backfill Material shall include full compensation for labor, materials, tools and equipment and incidentals involved and no additional compensation will be allowed.

REPAIR DRIVEWAYS

The scope of the work shall include the reconstruction, repair and resurfacing of driveways located in the Project area which are damaged or altered by the construction of the pipeline improvements. The Contractor shall coordinate the repair of driveways with the property owners. The repaired driveways shall be finish graded to match finished adjacent grades. The repair driveways shall be compacted to not less than 90% relative compaction. Final surfacing shall be at least as good as the driveway surfacing which was present prior to the beginning of construction. The repaired driveway shall be reviewed and approved by the City to the satisfaction of the property owner.

Payment

The Contract price paid for each Repair Driveway shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals involved and no additional compensation will be allowed.

CLASS 2 AGGREGATE BASE

Aggregate base shall be Class 2, ¾" maximum gradation conforming to the provisions in Section 26, "Aggregate Base", of the City Standard Specifications and these Technical Specifications.

The table of values of quality requirements in Section 26-1.02B, "Class 2 Aggregate" for Sand Equivalent is revised to read: Test Result – 30 Min., Moving Average – 32 Min.

Aggregate may include material processed from reclaimed asphalt concrete, Portland cement concrete, lean concrete base, cement treated base or a combination of any of the materials. The amount of reclaimed material may be 100% of the total volume of aggregate used. Aggregate shall conform to the grading and quality requirements specified in Section 26, "Aggregate Base", of the City Standard Specifications.

Aggregate base shall be spread and compacted in layers not to exceed 6 inches thick.

Payment

Aggregate base used in conjunction with backfilling of pipelines shall be paid as part of the Transmission Main lineal foot Contract price. The Contract price paid per ton of aggregate base furnished and installed for roadway and surface driveway construction shall include full compensation for all labor, materials, tools, equipment and incidentals and for the furnishing and placement of aggregate base material in accordance with City Standard Specifications, City Standard Plans, these Technical Specifications and as directed by the City and no additional compensation will be allowed.

TYPE A ASPHALT CONCRETE

Asphalt concrete (Surface) shall be Type A and shall conform to the provisions in Section 39, “Asphalt Concrete”, of the City Standard Specifications and these Technical Specifications.

The amount of asphalt binder to be mixed with the aggregate for Type A asphalt concrete will be determined by the City in accordance with California Test 367 using the samples of aggregates furnished by the Contractor in conformance with Section 39-3.06, “Proportioning”, of the State Standard Specifications.

Aggregate shall conform to the requirements of ½” maximum, medium gradation of Section 39-2.02, “Aggregate,” of the State Standard Specifications.

A tack coat shall be applied to all mating surfaces along lip of gutter and at conforms to existing pavement prior to placement of new asphalt concrete.

No separate measurement will be made for tack coat and binder required between paving courses, along surfaces of lip of gutter, and at conforms to existing pavement.

Asphalt concrete shall be compacted and finished in conformance with Section 39 of the City Standard Specifications.

Should the methods and equipment furnished by the Contractor fail to produce a layer of asphalt concrete conforming to the requirements, including straightedge tolerance, of Section 39-6.03, “Compacting,” of the State Standard Specifications, the paving operations shall be discontinued and the Contractor shall modify his equipment or furnish substitute equipment.

The complete surfacing shall be true to grade and cross section, of uniform smoothness and texture, compacted firmly and free from depressions, humps or irregularities.

The area to which paint binder has been applied shall be closed to public traffic. Care shall be taken to avoid tracking binder material onto existing pavement surfaces beyond the limits of construction.

A drop-off of more than 1 ½ inch will not be allowed at any time between adjacent lanes open to public traffic.

The Contractor's attention is directed to the "Maintaining Traffic" section of these Technical Specifications.

Payment

Full compensation for furnishing all labor, materials, tools, equipment and incidentals involved, and for doing all the work involved with Asphalt Concrete shall be considered in the Contract price paid per ton and no additional compensation will be allowed.

MOBILIZATION

Mobilization shall conform to the provisions of Section 11 "Mobilization" of the State Standard Specifications and to these Technical Specifications. The scope of the mobilization work shall include pre-construction photos. The Contractor shall provide the City with a digital file and one set of color prints of pre-construction photographs to be taken along the entire route of the Waterfall Gulch Transmission Main project. Photos taken within or adjacent to driveways or paved roadway sections shall be taken at distances of no more than 100 feet apart. Photos taken along the water main alignment in all other areas shall be taken at distances no more than 200 feet apart.

Each view shall contain the date, job name, and photo description. Photos shall clearly show the existing condition of pavements, surface improvements, fences, buildings and landscaping in the project area. Each photo shall be taken from a point four to six feet above the ground. All prints shall show good detail in both shadow and sunlit areas.

Prints shall be submitted to the City in a three ring binder with four photos per each 8-1/2"x11" sheet printed on high quality photo paper. Each group of prints shall be identified by a label which projects beyond the edge of filler and is easily recognized. Digital files shall be on a CD-ROM.

Upon review of these photos, the City may direct the Contractor to provide additional photos, or re-photograph specific facilities or site conditions.

All photographs which do not conform to these specifications and/or which, in the City's estimation, are unsatisfactory shall be re-photographed.

The pre-project photograph records shall serve as a basis for determination of subsequent damage due to the Contractor's operations.

Mobilization shall include participation in a conference with the City and shall include participation in regular progress meetings with the City. Mobilization shall include final Project walk through and the determination of remaining punch list items.

Payment

The Contract Lump Sum paid for Mobilization shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals involved and no additional compensation will be allowed.